SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MAY 1913.

GENERAL PHYSICS.

741. *Comparator for a Base Unit at Potsdam.* **F. Kühnen.** (Zeitschr. Instrumentenk. 33. pp. 1–9, Jan., 1913.)—An elaborate comparator of the usual type for comparison of 4-metre or 5-metre standard bars with 1-metre standards. Details are not given very fully, but there are good drawings and photographs. No results to indicate accuracy are given. P. E. S.

742. *The Reinecker Measuring Machine.* **A. Leman.** (Zeitschr. Instrumentenk., Beib. 4. pp. 33–39, Feb. 15, and pp. 45–48, March 1, 1913. Communication from the Physikal.-Techn. Reichsanstalt.)—The peculiarity of this machine as compared with the usual mechanical-touch machine, invented by Whitworth, is that indication of contact is shown by the rise of a dilute solution of alcohol in a capillary glass tube. Sectional drawings are given and some methods of adjustment are indicated. P. E. S.

743. *Test of Circle-dividing Machines.* **G. Foerster.** (Zeitschr. Instrumentenk. 33. pp. 10–19, Jan., and pp. 39–51, Feb., 1913.)—A considerable amount of theory is involved in comparing two machines (*a*) by Heyde, (*b*) by Hildebrand, the error of a single measurement and also the mean error for a number being worked out in each case. Calibration tables and curves are given, the greatest error found anywhere on either machine being 1·5 seconds of arc. P. E. S.

744. *Stereophotographic Surveying.* **O. Lemberger.** (Eng. News, 69. pp. 602–612, March 27, 1913.)—Gives a short history of the development of photographic surveying in Europe, with some examples of photographic location of certain railways, such as the Jungfrau Railway, and also examples of topographical surveys. The theory of photogrammetry is briefly explained, and also the theory and practice of stereophotogrammetry. The instruments used for the latter, the stereomicrometer and the stereocomparator, are dealt with, diagrams of their construction being given, with examples of their practical application. Finally, an instrument called the stereo-autograph is described, which automatically draws a map while an operator manipulates the stereocomparator. Contour lines may be drawn automatically on a map or on a photographic print. Illustrations are given of the use of the instrument for a survey of the Ostler Mountains in Tyrol, and other possible uses are suggested. A. W.

745. *Relation between the Deflection of a Beam and the Internal Stresses.* **A. Rejto.** (Rev. de Métallurgie, 10. pp. 262–277, Jan., 1913.)—The author has previously shown that the specific resistance of tenacious materials is a function of the actual tension, the uniform elongation per cent., and the angle of slip. The proof is now extended mathematically to the case of the deflection of beams, and is supported by actual tests. The conclusion is that the three functions mentioned are in reality the characteristic properties of the material. E. J. S.

746. *Resistance of Thick Cylinders to Rupture.* **Malaval.** (Rev. de Métallurgie, 10. pp. 214–219, Jan., 1913.)—In a tube of the proportions of gun practice, thickness about equal to inside diam., there are two distinct periods besides the elastic range. The latter is followed by the range of semi-elasticity or partial failure which is of sensibly the same duration in stress. With increasing applied pressures the area of overstressed metal widens radially outwards. Thus if the pressure is released the outer elastic zone is prevented from returning completely to its original shape by the permanent deformation of the inner plastic zone. The mutual action causes the unloaded tube to be stressed in tension in the outer region and in compression in the inner, so that it is in the condition of an ideal shrunk composite tube, *i.e.* one with an infinite number of indefinitely thin components whose mutual pressures are such that under rising internal pressure all parts reach the elastic limit simultaneously and bear equal parts of the load. The semi-elastic period ceases when the outside layer reaches the limit of elastic deformation, and is followed by the period of general failure. During this period, covering an increase of resistance much greater than those of the first two periods, all parts show an increase of resistance, the inner region being in compression and the outer in tension. It follows that the metal, whose capacity for deformation is greater in compression than in tension, can withstand very considerable internal strains. It is concluded that the ordinary shrinking process might be replaced advantageously by one involving initial overstraining of a solid tube. A gun so constructed would withstand a pressure of over 15,000 kg. per sq. cm. E. J. S.

747. *Some Static and Dynamic Endurance Tests.* **J. O. Roos af Hjelmsäter.** (Rev. de Métallurgie, 10. pp. 68–69, Jan., 1913.)—Experiments have been made to determine the endurance under static rotatory bending tests and to dynamic stresses produced by repeated shocks of definite energy, of various steels subjected to different thermal treatments. Rotatory bending tests were carried out on a machine of the Wöhler type rotating at 1800 revs. per min., the limit of endurance being taken as the stress in kg. per sq. mm. producing rupture after 1,000,000 revs. In the annealed state a steel of 0·4 % carbon gave a figure of 22, and a 0·65 % carbon steel showed 25, while after hardening at 850° C. and tempering at 550° C. the figures rose to 28 and 38 respectively. The test is not recommended for specification purposes, but should prove of great value in determining the material and thermal treatment suitable for a particular purpose. Dynamic tests were made in the Gustafsson machine, in which the specimen is clamped vertically at its lower end while

the upper end is subjected to alternate impacts at each end of a diam. from two pendulum spheres, each pendulum of 250 mm. length and 1 kg. effective weight making 50 impacts per min., the number of blows for fracture being determined. It is proposed to carry out further tests on highly phosphoric steels with the object of determining if fragility makes itself felt under the small fatigue shocks, but it seems probable that fragility is most obvious when the energy of the shock is considerably higher than the elastic limit of the metal so that rupture is effective in one or a few blows. F. C. A. H. L.

748. *Theory of a Shock Tensile Testing Apparatus and the Error involved in its Use.* **N. Davidenkof.** (Rev. de Métallurgie, 9. pp. 1184–1188, Dec., 1912.)—In the Amsler-Laffon type of tension shock-testing apparatus, the specimen is inserted between two shackles and the whole allowed to fall vertically. At a certain point the upper shackle is arrested; the lower one proceeds with a velocity sufficient to break the test-piece, and the kinetic energy of the lower shackle is measured immediately before and after fracture. This entirely neglects the work of deformation produced by the upper tup, which may under unfavourable conditions amount to 50 per cent. of that produced by the lower tup, and thus leads to results which are false. A large number of tests made by the author have shown that the upper shackle is not really arrested but rebounds, fracture actually taking place during the period of rebound. He has investigated mathematically the error introduced and the conditions under which it can be negleted. F. C. A. H. L.

749. *Shock Tests with Notched Bars for High-tension Steels.* **A. Gessner.** (Rev. de Métallurgie, 9. pp. 1171–1178, Dec., 1912.)—The author has been brought to the conclusion that the 75-kg. pendulum impact machine considered by Ehrensberger as generally suitable for test-bars 30 × 30 mm. in section with a round notch 4 mm. diam., is not suitable for all classes of steel. It has been found necessary to adopt a test-piece 10 × 30 mm. in section for high-tension steels, and a large number of tests have revealed interesting phenomena. Two types of fracture may occur and the resilience may vary by 50 per cent. according to the type of break produced. Further discrepancies are introduced by local deteriorations produced by the edge of the hammer, and by adopting a sharper-edged hammer the resilience may be diminished by 26 per cent. Similar phenomena occur, but are less frequent, in the larger bars, particularly in bronzes and forged steels, and the author considers that extreme fragility is best indicated by a more simple test, such as Heyn's bending test. F. C. A. H. L.

750. *Notes on the Brittleness Test.* **M. Derihon.** (Mech. Eng. 31. pp. 64–65, Jan. 17, 1913. Paper read before the Internat. Assoc. for Testing Materials.)—Long experience has shown that the brittleness test (Frémont drop weight) is not so stringent as is generally believed. By efficient heat treatment it is possible to reduce the rejections to 0·3 per cent. The small Frémont type of test-piece is to be preferred to the Copenhagen type, since it more readily reveals local defects. No trouble has been experienced owing to the sharp 1-mm. nick, which is simple and inexpensive to produce. Great importance is attached to a high velocity of impact and to arranging the anvil so as to take up the whole of the impact elastically. At the Derihon works the brittleness test has been generally adopted for determining the suitability of material. F. C. A. H. L.

751. *Tensile Yield-point and Collapsing Load of Struts.* **O. Greger.** (Rev. de Métallurgie, 10. pp. 298–302, Jan., 1913.)—Tests made on rolled mild steel plate and angle showed that the modulus of elasticity, calculated from collapsing tests on struts by Euler's formula, increased rapidly with increase of yield-point in tensile tests. When the yield is about 19 kg. per mm.^{2}, E is about 15×10^5 kg. per cm.^{2}. The value rises to E about 20×10^5 kg. per cm.^{2} when the yield-point is about 24 kg. per mm.^{2}. The shape of the curve suggests that E becomes nearly constant at the low values of yield-point, viz. 19 kg. per mm.^{2}. F. R.

752. *Influence of Temperature on Gaseous Turbulence.* **C. Schaefer** and **G. Frankenberg.** (Phys. Zeitschr. 14. pp. 89–93, Feb. 1, 1913.)—A criticism of Sorkau's work [Abstract No. 23 (1913)] on turbulence in gas currents through tubes. The authors confirm Sorkau's observation of three degrees of turbulence into which the steady Poiseuille current breaks up on successively increasing the speed beyond certain limits. But they controvert Sorkau's conclusion that the constant of turbulence I. has a simple relation to the absolute temperature, and that turbulences II. and III. are practically independent of the temperature. They show this by a simple application of Reynolds' dimensional method. They deduce a constant which fits the facts better than Sorkau's. This shows incidentally that the hydrodynamical equations also apply to turbulent streaming, which has sometimes been doubted. There is a complete analogy between the motion of solids in liquids and the turbulent motion of gases in capillaries. **G. Mie.** (Ibid. pp. 93–95, Feb. 1, 1913.) E. E. F.

753. *Measurement of Gas Velocities.* **W. Altberg.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1589–1594, Oct., 1912. Communication from the Inst. für Radiumforschung.)—The method depends on the resistance of a small sphere placed in the region of flow of a gas. The sphere is suspended by a thin wire (length L), and the resistance W measured by the displacement l; W being equal to $mg\,l/L$. W is also equal to $k\eta rv + b\delta r^2v^2$, where r is the radius of the sphere, v the velocity of flow, η the viscosity of the gas, and δ its density. k and b are constants equal to 100 and 1 respectively. Thus v can be calculated. The method is shown to be applicable to all ranges of velocity. E. M.

754. *Studies of Dendritic Structures in their Application to Metallography and to Electric Discharges.* **R. Arpi.** (Ark. för Mat., Astron. och Fysik, Stockholm, 8. 14. pp. 1–11, 1912.)—When a layer of liquid is arranged between two glass plates and the latter then separated, the liquid assumes a dendritic form. The author's experiments, made with machine oil, water, alcohol, and turpentine, show that these forms are of two kinds: positive, in which the structure (here formed by the air) grows inwards from the edge, and negative, or those which are formed by the partially displaced liquid. The configuration of the structure depends on the mass, viscosity, and adhesion of the liquid and on the capillary tension of the surface layer. The greater the speed at which the structure is formed the greater will be its surface, that is, the finer its branchings. Similar relations hold in the formation of metallographic structures on solidification, although in this case the action of crystallographic vectorial forces comes into play. Comparison of the two forms of dendritic structure shows, however, that such action is extremely small in many cases. Similar limiting surfaces must, in general, be expected when,

for instance, the explosion of a gas or liquid causes the latter to strive to distribute itself rapidly in a surrounding medium. The marked similarity between the structures formed by electric discharges and those obtained by the author is hence readily understood; especially close is the likeness in the case of Lichtenberg's figures. T. H. P.

755. *Relativity, Mass, Force, and Energy.* **R. D. Carmichael.** (Phys. Rev. 1. Ser. 2. pp. 161–178, Feb., 1913.)—In a previous paper the theory of relativity was treated in a new way [see Abstract No. 19 (1913)]. The same method is now applied to the treatment of mass, force, and energy, and their fundamental properties. In the derivation of these results the theory of electricity is not employed, but the ordinary relativity relations are obtained. E. H. B.

756. *Gravitation and Electricity.* **G. Borelius.** (Phys. Zeitschr. 13. pp. 972–978, Oct. 15, 1912.)—Shows, on certain assumptions regarding the potential due to several different positive and negative kinds of electricity, that the gravitational mass of an uncharged body is not necessarily proportional to the number of electrons it contains. E. E. F.

757. *Perrot's Experiment to Establish the Earth's Rotation.* **O. Tumlirz.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1481–1490, Oct., 1912.)—A discussion of Perrot's experiment proposed in 1859. [See Abstract No. 378 (1909).] E. H. B.

758. *The "Kilogramme" as a Unit of Force.* **E. Budde, K. Strecker.** (Zeitschr. Vereines Deutsch. Ing. 57. pp. 303–305, Feb. 22, 1913.)—Discusses the use of the word "kilogramme" in the sense of *m* and of *mg*; points out that the latter is good for engineers' statical calculations, but is becoming increasingly inconvenient in dynamical calculations. Suggests that the kilogramme-unit of *mg* be called a "kilobar"; so that 1 kilowatt = 102 kilobar-metres. A. D.

759. *The Errors in a Repetition-theodolite.* **O. Israel.** (Zeitschr. Instrumentenk. 33. pp. 61–68, Feb., 1913. Dissertation, Dresden, 1912.)—After treating the general theory of errors as applied to this kind of instrument, the author considers the special case of an instrument due to Heyde, the dimensions and component details of which are given. P. E. S.

760. *Deformation and Interference of Waves in Gases.* **L. Crussard.** (Comptes Rendus, 156. pp. 447–450, Feb. 10, 1913.)—The author first investigates the deformation of a plane wave traversing a perfect gas, and then considers the interference produced by certain disturbances. H. H. Ho.

761. *Automatic Registration of the Relation between Stresses and Deformation of Materials under Shock.* **A. Gagarine.** (Rev. de Métallurgie, 9. pp. 1189–1207, Dec., 1912.)—The author describes the construction and use of an apparatus for recording the behaviour of materials during shock tests. F. C. A. H. L.

762. *The Structure of the Atom.* **J. J. Thomson.** (Engineering, 95. pp. 232–233, Feb. 14; 266–268, Feb. 21; 300–302, Feb. 28; 346–347,

March 14, and pp. 397–398, March 21, 1913. Electrician, 70. pp. 1096–1097, March 21, and pp. 1133–1135, March 28, 1913. Abstract of lectures delivered before the Royal Inst.)

763. *Minkowski's Mechanics.* **F. J. de Wisniewski.** (Ann. d. Physik, 40. 2. pp. 387–390, Feb. 4, 1913.)—Mathematical. E. H. B.

764. *Relativity Equations.* **C. Cailler.** (Archives des Sciences, 35. pp. 109–139, Feb., 1913.)—An analytical treatment of the principle of relativity and its geometry. [See Abstract No. 2277 (1905).] E. H. B.

765. *Space-time Lines in Minkowski's "World."* **F. Kottler.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1659–1759, Oct., 1912.)—A mathematical treatise on this four-dimensional geometry. E. H. B.

766. *Molecular Theory.* **H. A. Lorentz.** (Archives Musée Teyler, 1. Ser. 3. pp. 43–74, 1912.)—A lecture on various modern aspects of molecular theory, including radio-active transformations, Brownian movements, and the laws of radiation. E. E. F.

767. *Relativity and Kinematics.* **E. Borel.** (Comptes Rendus, 156. pp. 215–218, Jan. 20, 1913.)—By consideration of three systems with velocities differing in magnitudes and directions, the author reaches the following conclusion :—A system which to observers on it increases uniformly in its translational velocity ought to appear in rotation to observers not on the system. [See Abstract No. 328 (1913).] E. H. B.

768. *Rainfall over the Balkan Peninsula.* **F. Trzebitzky.** [Review by M. Maraković.] (Meteorolog. Zeitschr. 29. pp. 517–522, Nov., 1912.)—Rainfall records are lacking in many parts of the Balkan peninsula, especially in Servia and Turkey, while in other parts they refer to different epochs or form incomplete series. The author gives tables for monthly, seasonal, and yearly amounts of rainfall for the period 1894 to 1905 from the records of 380 stations. Extrapolation was necessary where the observations were incomplete. The peninsula can be divided into two parts, according as the annual rainfall is greater or less than 1000 mm. The smaller area to the west has a fall of more than 1000 mm., the bounding isohyetal of 1000 mm. running in a NW.–SE. direction from NW. Croatia to the Gulf of Corinth. In an area near the Gulf of Fiume annual rainfall exceeds 2000 mm., while near the Bight of Cattaro, west of Montenegro, there is an annual total of 4700 mm., this being the wettest district of Middle Europe. Round about Constanza and Varna on the Black Sea the annual total is less than 500 mm. As usual the isohyetals run closely parallel to the contour lines. As regards seasonal variation the western side has a prominent minimum in summer, when south of Corfu that district is rainless. Winter on the western side is the wet season, the south being wetter than the north. The continental part of the district, comprising Bosnia, Servia, and Bulgaria, has a prominent summer maximum. The east side has a summer maximum in the north and a double maximum (summer and winter) on the coast of the Black Sea. In Greece the maxima occur in autumn or winter. The number of rain days has a maximum in the spring. The max. summer rainfall of the interior is caused by heavy thunderstorms. The rainiest months are Dec. (in the Mediterranean region) and June (in the north), the transition between the two being effected gradually. R. C

769. *Indications of the Seismograph at the Central Office of Meteorology and Geodynamics at Rome.* **G. Agamennone.** (Accad. Lincei, Atti, 22. pp. 175–179, Feb. 2, 1913.)—Tacchini has previously communicated the effects of mine and powder-mill explosions on this instrument, and it seemed not less interesting to record the effects produced by the shock of the fall of a heavy wall. The author's minute inquiries elicited the information that this shock which occurred on the morning of Jan. 3, 1913, or its reflection, was felt by persons all over an area of radius 350 m., or about 400,000 sq. m. The seismograph was at about 700 m. distance, double the extreme distance at which the shock was perceptible to the human senses, but nevertheless did not fail to register distinctly the passage of the waves through the soil over it. The commencement of the disturbance was at 4h. 25m. 14s. ± 2s., the first waves having a periodicity of about 1 sec., shortly succeeded by more rapid ones (0·3 sec.). Towards the NE. the first maximum had an amplitude of 0·1 mm. at 4h. 25m. 16s., followed by another at 4h. 25m. 17s., and the vibrations continued till 4h. 15m. 37s. On the NW. the max. amplitude (0·15 mm.) was at 4h. 25m. 17s., after which the movement rapidly diminished, the waves having at first a period of 0·6 sec., then more slowly and of periodicity 1 sec. till the end 4h. 25m. 37s. Thus the actual movement of the ground must have been very small, the amplification of the seismograph being 30 times, the values 0·1, 0·15 mm. giving 0·003 and 0·005 mm. as the true movements in the respective directions at the distance of the observatory. The maximum phase occurring at 2–3 secs. after the commencement indicates the proximity of the disturbance. The short period of the waves corresponds with those produced by the passage of a heavy vehicle some hours afterwards on the same day, giving rise to waves of period ⅓ sec. or so. For true seismic shocks arising in the vicinity and registered by the instrument the period is generally about 1 sec. and rarely less. Thus it must be admitted that the only cause of the disturbances registered was the fall of this heavy wall, of weight about 3000 tons, which, thrown down all at once upon the ground, propagated all round a very strong shock. F. W. H.

770. *Influence of Pressure-variations on the Weather in Austria North of the Alps.* **O. v. Myrbach-Rheinfeld.** (Meteorolog. Zeitschr. 30. pp. 13–23, Jan., 1913.)—A numerical value is assigned to the weather of each day, account being taken of cloud and precipitation only. The scale is drawn up from the consideration that the cause which usually produces cloud, namely, ascent of air, when carried far enough, produces also precipitation; and it is made continuous, starting from clear sky and passing through cloudy sky, overcast and showery, to long-continued and heavy rain. The change of pressure from one morning to the next, *i.e.* the values from which isallobaric maps for a 24-hour time interval are prepared, are also determined for each day, and curves are drawn showing the course of the weather throughout each month and the corresponding pressure-changes. It is found that, for the region considered, bad weather is associated with a simultaneous *increase* in pressure, and good weather with a *decrease*, the variations being roughly proportional to one another. The influence of pressure itself, as distinguished from change of pressure, is superposed upon this effect, especially for the high-pressure conditions of anticyclones. The first result is the opposite of that found for more level countries, and is accounted for by the Alpine chain, which causes the NW. winds of a region of rising pressure to ascend, so that bad weather is produced; while the SW. wind of a region of falling pressure is a descending one, and the weather in the locality is therefore dry and fine. R. C.

771. *Observations of the Neutral Points of Atmospheric Polarisation.* **C. Dorno.** (Meteorolog. Zeitschr. 30. pp. 71–80, Feb., 1913.)—The observations were made with a Savart's polariscope, and the calculation of the mean values given at the end of the accompanying tables are based only on the results of cloudless days on which the sky showed only trifling deviations from perfect transparency, and so the influence of cloud on these numbers does not require consideration. The first period, Oct., 1911, to May, 1912, gives very small values for the deviation of the Arago point from the "Anti-Solar" point. There are given values also for the respective positions of the Babinet and Brewster point, and more detailed monthly values both from morning and evening observations for all three points. The magnitudes of the deviations of the Babinet and the Brewster points vary somewhat as follows: Bw > Bb from Oct. to Feb. and in September, Bw < Bb in March to May (the clearest months), whilst in general Bb < Ag in Oct. to Dec. and March to May, but Bb > Ag in Jan., Feb., and Sept. A striking result not hitherto met with is the small difference between the Bb and the Ag values. A comparison of some of the author's results with those of Suring, Plassmann, Platania, and Busch is given in a short table, the latter generally showing the smaller values for Bb than for Ag. The effect of the various cloud-forms on the positions of these points is next considered, as also the presence of a remarkable halo on the afternoon of May 4; this was itself positively polarised, but inside there prevailed partly negative polarisation, the neutral lines going above and below through the inner (red) border, the points Bb < Bw lying in the red. With regard to the polarisation of the clouds themselves, the clearest stratus and cirro-stratus were in general unpolarised, and probably also the cirrus and alto-cumulus for the small traces of polarisation observed were no doubt due to small patches of intervening blue sky. As for the fracto-cumulus clouds, the author still leaves open the question as to their polarisation.

F. W. H.

772. *The Absorption of Light in the Atmosphere.* **G. Müller.** [Review by A. Defant.] (Meteorolog. Zeitschr. 29. pp. 511–516, Nov., 1912.)—Observations of light intensity according to different wave-lengths of the spectrum were made in the spring of 1910 at altitudes of 100, 1950, and 3260 m. in the island of Teneriffe, by means of the Glan-Vogel spectral photometer of the Potsdam Observatory, to determine the coefficient of transmission of the atmosphere as derived from the Bouguer-Pouillet formula. Curves are plotted giving the relation between coefficient of transmission and wave-length at each level, and curves already obtained for Washington, Potsdam, Mount Wilson, and Mount Whitney are added for comparison. The curves are very similar to one another, the coefficient being relatively low for low wave-lengths and high for high wave-lengths. The mean coefficient naturally increases with increasing altitude of the station, and at the highest stations (over 3000 m.) only 4 per cent. of red rays is absorbed. All the curves, except that for Mount Whitney (4420 m.), exhibit an inflection at λ0·570 to λ0·580, indicating selective absorption of the green rays, and it is therefore supposed that this phenomenon is confined to the lower layers up to about 3500 m.

The absolute temperature of the sun is deduced, both from Wien's and Planck's formulæ, to be about 6800° abs. R. C.

773. *Condensation Nuclei in the Atmosphere.* **A. Wigand.** (Meteorolog. Zeitschr. 30. pp. 10–13, Jan., 1913.)—It is known that nuclei are necessary for condensation, and that the forces which cause water-vapour to condense on them are either molecular, including physical adsorption and chemical absorption, or electrical, as when the condensation takes place on ions. Physical forces include surface-tension effects whereby water is more freely condensed on surfaces having small curvature than on those with large curvature; chemical forces include those producing condensation on hygroscopic substances; while the electrical forces favour condensation on small drops, but not on large ones, for the same charge. The amount of the so-called "dust" upon which condensation takes place can be determined by means of Aitken's dust-counter, and the number of nuclei per c.cm. thus computed, but the nature of the "dust" has been little investigated. The author carried out experiments to show that ordinary dust, such as that from a carpet or from coal, does not readily form nuclei; but, on the other hand, smoke from a cigarette or a petroleum lamp provides an infinite number of nuclei. Pure carbon dioxide, however, does not contain favourable nuclei. It is probable that smoke contains SO_2 and other hygroscopic gases, but it is known that ions are produced when a flame burns, and condensation may take place on these, provided they are the so-called "large" ions of low mobility, and not the "small" ions which are the usual objects of observation in measurements of atmospheric electricity. The author suggests that haze, which is known to be electrically charged, and to provide favourable nuclei for condensation, is composed largely of matter which is similar to the large ions produced during the burning process. R. C.

774. *Results of Unmanned Balloon Ascents in the North Polar Regions.* **H. Maurice.** (Comptes Rendus, 156. pp. 738–741, March 3, 1913.)—The earliest results obtained by Teisserenc de Bort and Hildebrandsson were published in 1907. Since then two other series of observations have been made in the same district in 1908 and 1909, and some of the balloons sent up in 1907 have been recovered later. All the balloons were sent up from Kiruna, lat. 67° 50′ N., and long. 17° 54′ E. (of Paris), at an altitude of 500 m. above sea-level. Seventy-two balloons in all were sent up, 41 of which were recovered, and 39 of these have given available results (15 of 1907, 16 of 1908, and 8 of 1909). The greatest height reached was 22,760 m. on Feb. 24, 1908, and the lowest temperature was —75·6° at 11,110 m. on Feb. 18, 1909. A table showing some of the principal results is given in the paper. Most of the balloons were recovered to the east of Kiruna, thus showing the predominance of west winds in the upper regions, confirming the polar vortex theory of Ferrel and the earlier observations of lofty clouds. But the balloons sent up on the coldest winter days always fell very near Kiruna, and often a little to the west of it. All the balloons showed that above a certain height the vertical [temperature] gradient vanishes or is very small, and often negative; above [this altitude] the temperature only shows very slight irregular changes. This layer was consequently named the isothermal layer, or *stratosphere*, by Teisserenc de Bort, who was the first to demonstrate its existence in the temperate zone. In our latitudes this layer is met with at an altitude varying from 7000 to 12,000 m., and its temperature varies from 45° to 60° C., whilst near the equator it is not found lower than about 15,000 m. or 17,000 m., and its temperature is not far from —85°. In Lapland but little seasonal variations seem to occur; the summer and winter ascents give but little different results, and the temperatures in the upper air "depend rather on the general meteorological condition than the season of the year." Comparison of balloon observations made simultaneously at Kiruna and at Trappes in France show that the isothermal layer is at a lower level in the former region than the latter (9800 m., temp. —49° Kiruna; 12,000 m. and —65° Trappes). At greater heights there is but little difference, though on the whole the more northerly station gives higher temperatures. Finally, comparing the results of balloon ascents made in different regions of the globe, we arrive at the somewhat unexpected result that at a very great height (such as 16,000 m.) we get a temperature of —50° to —60° in the circumpolar and temperate zones and —80° at the equator, exactly opposite to the temperature variations of the surface, which seems to indicate that the thickness of the atmospheric layers in which the vertical movements of the air take place is much greater in the equatorial regions than anywhere else.

F. W. H.

775. *Icebergs and the Temperature of Sea-water.* **J. Aitken.** (Nature, 90. pp. 513–515, Jan. 9, 1913.)—Some of the statements made by Barnes in his two papers [see Abstracts Nos. 1010 (1912) and 194 (1913)] being apparently incompatible, the author, referring to the researches on oceanic circulation by Carpenter (1873) and himself, describes some novel experiments. He moors a lump or rod of ice (from air-free water, coloured blue with aniline) in salt water; the blue ice-water rises to the surface, but does not sink at all; Barnes had withdrawn his statement that he believed in a rising current of ice-water. Aitken then drew a blue line in the water above the ice by passing a pipette with a capillary end, charged with blue salt water, horizontally through the water. The melting ice deflected this line upward close to the ice, but downward further away. Thus the fused ice-water kept close to the ice, and a cold downward current was set up further away. The appearance was not changed when a long rod of ice was placed in a deep vessel (1 ft.) which was cooled in its lower portions. Experiments on a large scale are needed. **H. T. Barnes.** (Nature, 90. pp. 671–673, Feb. 20, 1913.)—Referring to his letter of Dec., 1912 [see Abstract No. 194 (1913)], Barnes reproduces the micro-thermogram which he obtained in June, 1912, when he crossed the Atlantic from Europe viâ North of Ireland and Cape Race. The temperature of 9 or 10° C. dropped to 7° when they passed the "Cold Wall" between Gulf Stream and Arctic current and went down further to 4°, but rose again from 5° to 6½° in the neighbourhood of an iceberg. There was very little evidence of dilution of the sea-water by the ice-water, because the melting was slow; sea-water conductivities taken in July, 1912, at 26° C. fluctuated between 0·0477 and 0·05 without showing any regular influence of icebergs. East of the Straits of Belle Isle the conductivity rose in Oct., 1912, at 25°, rapidly for the first 180 miles, from 0·0486 to 0·052, and kept then nearly constant up to 450 miles. The great Arctic current seems to be of a lower order of salinity. There is no reply to Aitken.

H. B.

776. *Seiches of Lake Inawasiro.* (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 24–29, Feb., 1913.)—The lake lies 570 m. above sea-level; it is surrounded by steep mountains and fairly regular in shape, 12 by 10 km.; the mean depth is 51 m., the max. depth 112 m. The observations were made by students of Tokohu University under Honda and with his instruments. Oscillations were observed of two periods, 19·11 and 8·89 mins. Oscillations in a model of the lake, scales 1 : 25,000 and 12 : 10,000 (length and depth), were produced by a vibrating vertical rod; the periods deduced from these experiments would be 19·53 and 9·11 mins. There seem to be

three nodal lines. As regards the origin of the seiches, it is suggested that the wind heaps up the water in certain parts; when the wind decreases or changes its direction, the water returns and causes seiche oscillations.

H. B.

777. *Seiches of Lake Tōya.* **K. Sano.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 17–22, Jan., 1913.)—In 1905 Honda obtained a period of 9·29 mins. from his observations of this lake, the calculated period from Marian's formula being 11·2 mins. Had allowance been made for the presence of the island at the centre of the lake better values would have been obtained; but the present author, calculating the period on a different hypothesis from that assumed by Honda, found a closer agreement between the calculated and observed period. The lake is nearly circular in form, and has an island also circular in form and almost concentric with it, so that we may consider the water to be contained between two coaxial cylindrical surfaces with vertical axis, the mean depth being $9{\cdot}58 \times 10^3$ cm. If a and b be the external and internal radii and h the depth, we have $a = 5 \times 10^5$ cm., $b = 1{\cdot}2 \times 10^5$ cm., $h = 9{\cdot}58 \times 10^3$. Figures are given showing the nodal lines where the vertical component velocities of the water vanish in different assumptions, and the possible periods of oscillation are calculated. Instead of Honda's value, the author obtains a period of 10·24 mins., being greater than that observed by about 10 %. A shorter period observed by Mori in 1911, 4·5 mins., may correspond to one of the other possible modes of oscillation (8·9 or 8·4 mins.), but may be due to a change of depth in the water of the lake.

F. W. H.

778. *Production of Stationary Tides of the Second Order in an Ocean possessing any Law of Depth.* **E. Fichot.** (Comptes Rendus, 156. pp. 211–213, Jan. 20, 1913.)—The author discusses a previous paper by Rayleigh [see Abstract No. 1155 (1903)]. The conclusion drawn is that nothing will oppose the production of a stationary tide of the second order, whose deviation from the tide proper varies with the extent of the permanent circulation areas, and it will depend on the law of depth and the continental distribution.

H. H. Ho.

779. *An Important Problem in Cosmical Physics.* **C. Störmer.** (Comptes Rendus, 156. pp. 450–453, Feb. 10, 1913.)—The author gives further results [see Abstracts Nos. 1327 (1911), 368 (1913)] on the problem of finding the motion of an electrified corpuscle in the field of a simple magnet, by supposing that the corpuscle is subjected to the action of a central force emanating from the magnet and inversely proportional to the square of the distance. From the equations developed the trajectories of the particles, equipotential lines, and points of equilibrium are discussed, and a series of interesting consequences deduced.

H. H. Ho.

780. *A Mechanical Problem and its Applications in Cosmical Physics.* **C. Störmer.** (Comptes Rendus, 156. pp. 536–539, Feb. 17, 1913.)—A previous investigation [see preceding Abstract] on the trajectories of electrified corpuscles in a simple magnetic field is shown capable of a mechanical interpretation very useful for the study of trajectories. Applications are made to Arrhenius' theory of the aurora borealis, in which he supposes that material particles are ejected from the sun by radiation-pressure; to the theory of the solar corona; and to Birkeland's ideas upon the zodiacal light, comets, Saturn's rings and cosmogony. [*Errata*, p. 926, March 17, 1913.]

H. H. Ho.

781. *Detection of General Magnetic Field of the Sun.* **G. E. Hale.** (Terrestrial Magnetism, 17. pp. 173–178, Dec., 1912.)—In 1908, shortly after magnetic fields had been detected in sun-spots, attempts were made at the Mount Wilson Solar Observatory to observe the Zeeman-effect due to the general magnetic field of the sun. The investigation was resumed in 1911, and in 1912 with the greater power of the 150-ft. tower telescope and 75-ft. spectrograph. The dispersion was 4·9 mm. to the Ångström unit, using the third order of a large Michelson diffraction grating. A Nicol prism is placed in front of the spectrograph slit, in combination with a compound quarter-wave plate made up of sections of mica 2 mm. wide, the principal sections of successive strips making an angle of 45° with the slit and 90° with each other.

A series of photographs of the spectrum near the D lines were made with the third order, and with the slit adjusted to various latitudes on the central meridian of the sun. With very few exceptions the resulting measurements of the displacements of the lines showed that these were positive in the northern and negative in the southern hemisphere, their magnitude decreasing from a maximum near 50° north or south latitude, to zero near the equator. A marked feature of the observations lay in the fact that only a few of the solar lines appeared to be thus affected, the others showing no shifts, although they were known to give large Zeeman-effects in the laboratory. This may be due to differences of level in the solar atmosphere. Anothor series of observations is in progress, using a solar image 16½ in. in diam. C. P. B.

782. *Integrated Spectrum of Milky Way.* **E. A. Fath.** (Astrophys. Journ. 36. pp. 362–367, Dec., 1912. Contribution from the Mount Wilson Solar Observatory, No. 63.)—The results of the Harvard spectroscopic survey indicate that over 52 % of the 32,000 stellar spectra already investigated belong to the A type, and that the ratio of A-type stars to all other types increases as the brightness decreases. Two-thirds of the stars investigated in the Milky Way are of the A type. The present note gives the result of an investigation of the integrated spectrum of the Milky Way, undertaken at the Mount Wilson Observatory with a special spectrograph. Exposures of from 30 to 74 hours were given, and the resulting photographs indicate that the spectrum of the integrated light from various regions of the Galaxy is approximately of the solar type. The G group of lines is faintly indicated, and the strong calcium absorption lines H and K, with several bands further towards the ultra-violet. C. P. B.

783. *Relation between the Spectra and other Characteristics of the Stars.* **H. N. Russell.** (Amer. Philosoph. Soc., Proc. 51. pp. 569–579, Oct.–Nov., 1912.)—The absolute magnitude of stars is taken as the stellar magnitude they would appear to have if each star was brought to the standard distance of 32 light years (parallax of 0·10″). Such absolute magnitudes, when plotted against the spectral types, show that most of the stars belong to a series in which the fainter are redder than the brighter, while a few outstanding stars of each spectral class greatly exceed in brightness those belonging to this series. Hertzsprung has called these "dwarf" and "giant" stars. The relation between absolute magnitude and spectral type appears to be independent of the origin of the particular star or group under consideration, and can be represented by $\text{Abs. Mag.} = 0{\cdot}5 - 2{\cdot}2(\text{Sp.} - \text{A})$, in which the spectrum B is counted as 0, A as 1, F as 2, etc. Of 213 stars with fairly reliable parallax and spectrum determinations, 69 % have an absolute magnitude within one of that computed by this formula. First magnitude giant stars, not included in above consideration, can be seen at enormous distances, and consequently form a disproportionate part of the stars visible to the eye; few are near enough for reliable parallax measurements. The respects in which giant and dwarf stars differ, besides in brightness, are considered in binary stars, with orbital elements and apparent brightness known; the ratio L^3/M^2 (L = combined light; M, combined mass) can be determined without knowing the parallax. The author has, by statistical methods, extended this principle to stars physically connected, but whose orbits cannot be computed. Three hundred and fifty stars have been so investigated, and found to fall into two series of high and low luminosity per unit mass respectively. In these the mean absolute magnitudes agree almost perfectly with those derived for other groups. The author concludes that a "B" class star is 3 to 4 times the sun's diameter, 15 times his area, 200 times as bright, and therefore 15 times his surface brightness. Similarly, "A" class stars have a surface intensity of 5 times the sun's. Faint stars of classes "K5" and "M" average only 1/100th of the sun's light, with masses exceeding half the sun's; such diminution of surface brightness with increased redness, proved in the dwarf stars, supports the hypothesis that spectral class differences are due to surface temperature differences, and this also applies to giant stars. The latter, nearly equal in brightness for all spectral types, must decrease very rapidly in density with increasing redness. If stars are arranged in order of increasing density, the series begins with giant stars of class "M," passes through giant series to "B," then through the dwarf stars to the faint red. This agrees with the theoretical behaviour of masses of stellar gas left to gravity and radiation. The highest temperature will be attained at a density for which the departures from the gas laws are considerable, but probably before the density is as great as water. "B" and "A" class stars (the hottest) are found to have one-fifth the density of water. The author's hypothesis is that giant and dwarf stars represent different stages in stellar evolution, the former being young stars growing hotter, and the latter old stars growing colder and redder. H. F. H.

784. *Observations of R Cygni near Minimum.* **T. E. Espin.** (Roy. Astronom. Soc., M.N. 73. pp. 164–165, Jan., 1913.)—Observations were made during the minimum of this interesting variable, 1912 Sept. 2–Nov. 29, with a small spectroscope of low dispersion capable of showing the spectrum of Nova Lacertæ when only 12th mag. Examination of the star disc with high powers failed to show any signs of nebulosity. C. P. B.

785. *Motions and Distances of Bright Stars.* **H. C. Plummer.** (Roy. Astronom. Soc., M.N. 73. pp. 174–191, Jan., 1913.)—In a former paper attention was drawn to the probability of certain star groups (Class A) moving nearly parallel to the plane of the Milky Way. The present paper deals with the study of the stars of class (B—Bs) from a similar point of view. The general conclusion is that the stars of Secchi's type I, with apparent magnitudes 3, 4, and 5, considered as a whole, are very thoroughly distributed in space. The results are discussed in relation to Schwarzschild's ellipsoidal hypothesis. C. P. B.

LIGHT.

786. *Prism Spectrograph.* **P. Weiss** and **R. Fortrat.** (Archives des Sciences, 35. pp. 5–27, Jan. 15, 1913.)—Describes two similar spectrographs, one having flint-glass prisms, the other quartz prisms, both instruments having high resolving power. The principle of autocollimation is employed. Light from a narrow slit is reflected by a total-reflection prism on to a concave mirror; this mirror renders the light parallel and sends it through a train of five prisms, whose refracting angles are about 63°, and through a right-angled prism of half this angle, whose back face is silvered, thus causing the light to return through all the prisms to the mirror, which focusses the light on the photographic plate. The dispersion, therefore, is equal to that obtained with eleven prisms. The prisms are mounted on a Hamy train, ensuring the equality of the angles between the faces of consecutive prisms when they are turned; hence a ray traversing the first prism at minimum deviation traverses all the others under the same condition. Special features of the apparatus, such as the position of the slit, the separating power, the loss of light by reflection, and the optical properties of the glass used for the prisms, are discussed at length. In the quartz prism instrument a quartz lens was used instead of the concave mirror. The quartz prisms were cut with the optic axis parallel to the refracting edge, a method suggested by A. Cotton, and the refracting angles varied from 64° 55′ 15″ to 65° 2′ 30″. A table is given comparing the dispersions obtained with other spectrographs. Many studies of band spectra and of the Zeeman-effect in absolute measure have been made with the instrument. With long exposures lines have been photographed whose feeble intensity renders it impossible to study them with a grating. Among others, important new lines have been observed in the very faint violet band of the Swan spectrum. A. W.

787. *New Application of Röntgen Rays: Micro-radiography.* **P. Goby.** (Comptes Rendus, 156. pp. 686–688, March 3, 1913.)—Describes, with diagrams and constructional details, an apparatus by means of which radiograms of microscopic objects, such as diatoms, foraminifera, etc., may be obtained with such sharpness that they may be enlarged 15 or 20 times with little loss of definition, and hence the internal structure of the objects may be easily studied. A. W.

788. *Radiometer Attachment for Monochromatic Illuminator.* **W. W. Coblentz.** (Frank. Inst., Journ. 175. pp. 151–152, Feb., 1913.)—In cases where the effect of light-stimuli is being investigated it is desirable to know the energy value (mechanical equivalent) of the different wave-lengths employed, and it is usually desirable to reduce the energy of the different spectral regions to the same value. For this purpose it is necessary to use a radiometer whose working is independent of the frequency of the stimulus. The most useful radiometer which requires but little care is a thermopile. The Bi-Ag thermopile is much more sensitive than an iron-constantan one. In the present case it is mounted securely in an air-tight metal box fitted with a quartz window. The diam. of the Bi-wire is 0·1 mm., and that of the Ag-wire 0·04 mm. The metal case moves in a vertical slide in front of the

spectrometer slit, so that it can be brought in front of the slit or be raised above it at will. The thermopile is connected to a galvanometer whose readings will be a measure of the energy of the light falling on the junctions. The apparatus is being made by Hilger. A. W.

789. *"Cellit." A Non-inflammable Cinematograph Film.* **C. R. Hennings.** (Photographic Journ. 58. pp. 10–13; Discussion, pp. 13–14, Jan., 1918.)—The celluloid of the ordinary cinematograph film is a compound of nitro-cellulose and camphor. It is highly combustible, burning rapidly and in such a manner as to quickly involve surrounding objects, while the gases evolved, which include carbon monoxide, oxide of nitrogen, and hydrocyanic acid are highly poisonous. On the other hand, the "cellit" film is practically non-inflammable, and, so far as the adhesion of the emulsion and the suppleness of the base are concerned, the two types of film are identical. It is almost impossible to distinguish the two by mere outward appearance. "Cellit," however, expands more than ordinary film in developing, fixing, etc., the expansion with celluloid being 0·8 %, with "cellit" 1·2 %. The film after drying assumes its original size, and no shrinkage, such as would lead to inaccuracy in the perforations, occurs with several months' storage. The new film is developed, fixed, and washed in the same manner as the celluloid film, and the pictures are identical and may be coloured in a similar way. A. E. G.

790. *Formation of Mirrors by Scattering due to Kathode Rays.* **G. Rümelin.** (Phys. Zeitschr. 13. pp. 1222–1223, Dec. 15, 1912.)—A description is given of apparatus suitable for quickly obtaining a thin film of metal by scattering produced by kathode rays. This is a most convenient manner of forming thin layers of different metals for the purpose of studying their optical properties. A. E. G.

791. *Absorption Curves of Colloidal Silver Solutions.* **R. Gans.** (Phys. Zeitschr. 13. pp. 1185–1186, Dec. 15, 1912.)—The author has recently shown [Abstract No. 1328 (1912)] that the ultra-microscopic particles in colloidal gold solutions must be of nearly spherical form. He is now investigating the form of the particles of a silver solution, and by way of preliminary gives the calculated absorption curves corresponding to twelve different assumed forms of the particles. The absorption curve is seen to depend largely on the form of the particle. Hence, when the measures necessary to obtain the actual absorption curve are concluded, it should be possible to deduce from them the required form. In making the calculations, data given by E. Müller [Abstract No. 1357 (1911)] were used, and the particles were assumed to be ellipsoids of rotation infinitely small compared to the wave-length of light. The twelve values assumed for the ratio of axes include the values 0 and 1, covering the cases of sphere, disc, and rod. A. E.

792. *Refractive Index Determinations with the Microscope.* **H. E. Merwin.** (Washington Acad. Sci., Journ. 3. pp. 35–40, Jan. 19, 1913.)—Various immersion liquids have been in use for the determination of refractive indices over the interval 1·33 to 1·80; mixtures of amorphous sulphur and selenium have been found useful over the range (for sodium light) 2·1 to 2·4. In the present paper immersion media are described to fill the gap 1·80 to 2·10, and to extend the series beyond 2·4, or in special cases, particularly when a refractometer is not at hand for standardising the liquids, take the place

of media hitherto used. For the latter purpose solids have been found which may be mixed in given proportions by weight to produce permanent standard media. These are either vitreous (more or less rigid) or liquid (fluid). For details the original paper should be consulted. A. W.

793. *Double Refraction produced by Distortion of Elastic Bodies, according to Volterra's Theory.* **O. M. Corbino.** (Nature, 90. pp. 540–541, Jan. 16, 1913.)—A republication of researches by the author and G. C. Trabacchi, hitherto only published in Italy [Abstract No. 1159 (1909)], in which it is shown how, starting from Volterra's general formulæ, the double refraction produced by distortion of a cylindrical ring of elastic substance, in which a radial or parallel slot has been cut, and the cut surfaces then glued together, may be mathematically deduced, and such deductions experimentally verified. Photographs of the various effects obtained are reproduced. W. H. Si.

794. *Limits of Application of Polarisation Photometers to Investigations on Diffusely Reflecting Surfaces.* **V. Nåvrat.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1289–1296, July, 1912.)—The author discusses the extent to which "shiny" reflection from a so-called matt surface may lead to polarisation, and hence exclude the use of polarisation photometers for studying the intensity of light reflected therefrom. Previous investigations show that the effect is more pronounced when the light strikes the surface at an oblique angle, and when the material is coloured [see Abstract No. 666 (1912)]. Some detailed numerical experiments on this point are described, and the results collected in tabular form. These show that true diffused reflection is characteristic of surfaces which consist of permeable cloudy media. In order that such directly reflected light as exists may be practically unpolarised the angle between the incident and reflected ray should be as small as possible, preferably within 10°. In the case of plates composed of compressed powder, and presenting surfaces the size of the particles on which is large compared with the wave-length of light, polarisation is to a great extent suppressed and the safe angle of inclination may be increased somewhat. J. S. D.

795. *Non-focal Images of Gratings.* **M. Wolfke.** (Ann. d. Physik, 40. 1. pp. 194–200, Dec. 31, 1912.)—Discusses some experiments which show that Abbe's theory of diffraction images requires revision. In the general case, when several chief maxima come into operation, the image is distinctly affected by a displacement in the direction of the principal axis. The original image returns in all positions distant from the focal plane by a multiple of γ^2/λ, where γ is the element of the grating and λ the wave-length. The greater the distance from the focal plane the less distinct is the image, but the fringes are distinctly seen even at a distance of $4\gamma^2/\lambda$. A new derivation of the image equations, rendered necessary by these observations, is given. [See Abstracts Nos. 616, 1474 (1911).] E. E. F.

796. *Optical Constants of Certain Metals in the Infra-red.* **K. Försterling** and **V. Fréedericksz.** (Ann. d. Physik, 40. 2. pp. 201–232, Feb. 4, 1913.)—Using a Wadsworth monochromator and a polarisation spectrometer in conjunction with a bolometer, the optical constants were determined for Ag, Cu, Au, Pt, and Ir. The results are tabulated and graphed, and theory given, the experimental and calculated results being in good agreement, though some discrepancies are noted. A. W.

797. *Molecular Impact and the Emission of Light.* **H. Pettersson.** (Phys. Zeitschr. 14. pp. 109–112, Feb. 1, 1913.)—It is assumed that the state of vibration of a resonator varies with the time elapsed since collision. Immediately after collision the vibration is irregular, like that of white light. Most of the components are strongly damped, but those corresponding to the proper frequencies of the resonator gradually emerge and finally survive the others. When the time between collisions is long, as in rarefied gases, the proper frequencies are the only ones which give a measurable effect. This observable emission and absorption thus depends upon the frequency of molecular impact, and certain phenomena lately discovered by Ångström, v. Baur, and Wood may be explained on these lines. E. E. F.

798. *Rod Vision.* **O. Lummer.** (Phys. Zeitschr. 14. pp. 97–102, Feb. 1, 1913.)—Quotes some observations to show that on a clear star-light night vision is chiefly a function of the rods, and is therefore colour-blind. Most stars are seen by indirect vision. The Pleiades when looked at straight shrink to a few points of feeble luminosity, whereas they produce a bright silver-white image when seen with the circumfoveal areas of the retina. An accurate knowledge of the curves of visual intensity in the spectrum has only become possible by the realisation of the ideal black body, and with the help of the spectrum flicker photometer. The maximum of sensitiveness is a wave-length 5550 for the cones and at 5150 for the rods. The observations quoted were made in a balloon voyage in the full moonlight and during a stay in the Iser Mountains. Stars with a "rod-white" luminosity could be made to disappear by bringing the colour-discriminating cones into activity. Their disappearance was often marked by scintillation or by sudden displacements.

E. E. F.

799. *Projection of Natural Colours.* **A. Guébhard.** (Comptes Rendus, 156. pp. 127–129, Jan. 13, 1913.)—A paper discussing the theoretical possibility of obtaining a reversible arrangement for the automatic reconstitution of the natural colours of objects in projection. A. W.

800. *Electric and Magnetic Double Refraction.* II. and III. **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr., Math.-phys. Klasse, 7. pp. 832–843, and pp. 861–878, 1912.)—A theoretical treatment with special reference to the anomalous dispersion and absorption lines [see Abstract No. 66 (1913)].

E. H. B.

801. *Resonance Spectra of Iodine by Multiple Excitation.* **R. W. Wood.** (Phil. Mag. 24. pp. 673–693, Oct., 1912. Phys. Zeitschr. 14. pp. 177–189, March 1, 1913.)—In previous work the spectra excited by many widely separated wave-lengths have been studied [see Abstract No. 42 (1912)], but the author came to the conclusion that no great advance could be made until some method was devised for varying the wave-length of the exciting light by very small amounts. A step has now been made in that direction, and some surprising results have been obtained which throw light on some points hitherto difficult to explain. The resonance spectrum suffers profound changes when small changes occur in the structure of the exciting line. The complexity of the iodine absorption spectrum has been greatly underestimated. Every increase in resolving power brings more structure into view, and the elaborate maps and tables of wave-lengths which have been published from time to time are absolutely worthless. For instance, seven

sharp absorption lines of iodine are now found *within* the green mercury line emitted by the quartz mercury arc, where there is only a single line on Hasselberg's great map of the iodine spectrum. In one of the yellow mercury lines 14 absorption lines are found, and 12 in the other. When, therefore, the resonance spectrum is excited by one or other of these lines, from 7 to 14 different frequencies may respond to what might be called monochromatic excitation. It becomes at once clear why a small change in the distribution of intensity in the exciting line or in its structure may modify the resonance spectrum. The author has even succeeded in modifying the structure by the use of ray filters which remove certain frequencies from the exciting line: *e.g.* by passing the green light from the mercury arc through bromine vapour before it enters the iodine vapour a change can be produced in the resonance spectrum excited by the green mercury line. The same method could doubtless be applied to the sodium resonance spectrum, but the iodine vapour is very much easier to handle. The resonance spectra, as a whole, was photographed with a large 8-prism spectrograph, and for studying the structure of the resonance lines themselves, as affected by the structure of the exciting line, a concave grating was employed. The absorption for frequencies falling within the spectral range covered by the exciting rays was studied first with a 6-in. plane grating in the 4th order spectrum used with a spectrometer of over 2 m. focus, and afterwards with a 40-ft. spectrograph. This spectrograph is the most powerful in the world, except possibly Michelson's 10-in. grating instrument. It was put together out of odds and ends. The piers were improvised from two 6-in. water mains slightly damaged by frost. The plate-holder and slit are supported on a shorter piece of water-pipe. The camera consists of two wooden boxes, one sliding within the other, joined to the end of the tube by black cloth, which does not transmit vibration. The long tube was made by nailing 8-in. boards together. The mercury arc was employed as a source of light. The plane grating gave a resolving power of 300,000 in the 4th order.

The absorption spectrum of iodine, which has a general resemblance to the channelled absorption of sodium vapour, presents a wonderful appearance in the large spectrograph, nearly the entire visible spectrum being filled with thousands of lines, probably over 50,000. Comparison of a portion of the absorption spectrum with the corresponding portion of Hasselberg's map shows that Hasselberg's lines mean nothing beyond indicating roughly the position of some of the groups of lines. "A study of these two pictures cannot but furnish food for thought to astronomers working at the problem of the canals on Mars." The absorption of sodium is equally complex. Sodium, however, exhibits only a single faint line within the green mercury line; hence the mercury arc is incapable of stimulating sodium vapour to appreciable fluorescence. A large number of lines in the absorption spectra of bromine and iodine coincide. There appear to be more coincidences than can result from accident, and the author suggests that there may possibly exist in the two elements identical systems of electrons which give rise to similar frequencies in the two molecules. The iodine absorption spectrum observed with sunlight is far superior to the solar spectrum for testing large gratings. The author has succeeded, by the use of filters, in separating the resonance spectrum of iodine due to the green mercury line from that due to the two yellow lines. With fairly high dispersion, the lines excited by the green ray are seen to be in reality close doublets accompanied by fainter companions. The series seen consists of 25 pairs, two of which are missing. Certain lines were found to be missing in the resonance spectrum of sodium vapour, and this peculiarity is probably characteristic of all resonance spectra. The law of spacing is not the same for iodine and sodium. For sodium the wave-length intervals, but for iodine the frequency-differences, are approximately constant. They are not strictly constant, however, and it seems possible that the discrepancies may be the result of slight perturbations which modify the periods. The wave-lengths were determined from photographs. Under high resolving power a very complicated structure is found, which appears to be a result of multiplex excitation, *i.e.* excitation by lines broad enough to excite a number of adjacent frequencies. The general appearance of the groups of resonance lines is like a highly (80-fold) magnified image of the group of absorption lines falling within the green mercury line. The author was at first inclined to think that each line in a resonance group resulted from the stimulation of a definite absorption line, but no longer believes so. The component lines accompanying the doublets are quite different for the Cooper Hewitt commercial glass lamp and for the mercury arc in quartz. The strong doublets are shifted towards the violet in the case of excitation by the latter high-temperature arc ; it is not an actual shift, but merely a change in distribution of intensity among the lines forming the groups. In addition to this certain lines appear in one case which are absent in the other. A further study of the remarkable transformation of the resonance spectrum into the band spectrum, which occurs when the iodine vapour is in helium at a pressure of a few mm., has been made. The other gases of the He group behave in the same way, and the band spectrum can be brought out by the presence of the air at 1 or 2 mm., though the intensity of fluorescence is enormously weakened. In previous work the fluorescence of mercury vapour was found to be destroyed by raising the temperature of the quartz flask with a blast-lamp. The same thing is true of iodine, which, however, loses its luminosity at a temperature so low that the effect can be shown with a tube of soft glass heated with a small Bunsen flame. A. E.

802. *Arc and Spark Spectrum of Lead.* **F. Klein.** (Zeitschr. wiss. Phot. 12. pp. 16–30, Feb., 1913. Extract from Dissertation by same author.)—Describes measurements of the lines in the arc and spark spectrum of lead from $\lambda = 7228$ to $\lambda = 2088$ made with a Rowland concave grating, the iron arc being used for a comparison spectrum. Wave-length tables are given in international Å. units to two or three decimal places. A. W.

803. *Arc and Spark Lines in Canal-ray Spectra.* **J. Stark.** (Phys. Zeitschr. 14. pp. 102–109, Feb. 1, 1913.)—The ratio of the intensity of the spark spectrum lines to that of the arc lines is higher when they are excited by rapid kathode rays (negative glow) than by slow kathode rays (positive light-column at low pressure). The emitters of the spark lines are probably atomic ions of high valency, with a larger number of positive elementary charges than the emitters of the arc lines. One element may thus possess several groups of spark lines, due respectively to bivalent, trivalent, or quadrivalent ions. J. J. Thomson has found that in canal rays in oxygen and nitrogen both univalent and bivalent oxygen and nitrogen ions occur. The difference in the max. velocity of the two species of lines, observed in the canal-ray Doppler-effect, is easily accounted for by the difference in valency n, the velocity acquired being proportional to $\sqrt{n}$. E. E. F.

804. *Appearance of Helium and Neon in Vacuum Tubes.* **J. N. Collie** and **H. S. Patterson.** (Nature, 90. p. 699, Feb. 27, 1913.)—An examination of

the spectrum lines characteristic of helium and neon shows that in the secondary spectrum of hydrogen there are a large number of lines very close to the important lines of neon. There are 57 of these differing by less than a quarter of an Ångström unit. Of the six principal Ne lines, five are paralleled in the secondary hydrogen spectrum. There are similar parallelisms between Ne and He. **A. Fowler.** (Ibid. 91. pp. 9–10, March 6, 1913.)—Fowler points out that there is nothing remarkable in the occurrence of a considerable number of approximate coincidences between lines belonging to the hydrogen and neon spectra respectively, in view of the large number of lines due to both elements in the region referred to. Moreover, a quarter of an Ångström unit is far beyond the limits of error of modern spectroscopy. Of the hundred brightest lines of Ne, only six are found in hydrogen within the probable limits of error, and only one of the six of max. brightness is among them. The helium coincidences are even less suggestive of a connection as the He lines occur in series, and no conclusion could be drawn from an approximate coincidence with isolated lines.

E. E. F.

805. *Absorption Spectra of some Uranyl Salts.* **A. Mazzucchelli** and **O. G. d'Alceo.** (Accad. Lincei, Atti, 22. pp. 41–43, Jan. 5, 1913.)—Continuing their work on these compounds [Abstract No. 415 (1913)], the authors have compared the absorption spectra of uranous chloride, with and without the addition of an excess of urea, and of uranous chloride and sulphate with and without addition of glycocoll. The presence of urea has no effect on the spectrum, but reproductions of the spectra with and without glycocoll show that the latter has a marked influence, the absorption being greater, especially at the ends of the spectrum. W. H. Si.

806. *Zeeman-effect.* **W. Voigt.** (Ann. d. Physik, 40. 2. pp. 368–380, Feb. 4, 1913.)—The author shows that the Lorentz theory may be modified so as to represent the Zeeman-effect of close triplets and doublets [see Abstract No. 419 (1913)]. He suggests the following substitute for Preston's law: "The characteristic line systems (simple line, doublets, etc.) of one and the same series or of similar series have similar and numerically equal parameters in the (modified Lorentz) magneto-optic equations corresponding to them." If the constituents of the system are separated by a considerably larger interval than the magnetic separations of the simple lines, the formulæ give Zeeman-effects, following Preston's law. If, however, the interval is of the same order or smaller the theory indicates the deviations observed.

J. M.

807. *Relative Intensities of Green Hg Line and its Satellites.* **H. Nagaoka** and **T. Takamine.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 2–10, Jan., 1913.)—Describes in detail the method of determining the relative intensities of the satellites of the green Hg line, referred to in the authors' previous paper [Abstract No. 424 (1913)]. Light from a Nernst lamp (110 volts, 1 amp.), placed in a large wooden box, was made parallel by a quartz lens, and passed the photographic plate under examination at normal incidence. The current feeding the lamp was carefully kept constant during the observation. The photographic plate was attached to the end of a short tube which could be moved by a micrometer screw, and the film surface of the plate was almost in contact with the slit (17 mm. × 0·05 mm.). An iron-constantan thermopile of 24 junctions was placed behind the slit and received

the light passing through the slit. A delicate galvanometer was connected to the thermopile and was read when successive displacements equal to the slit width were given to the plate. Special precautions were taken to avoid uncertainty of readings due to temperature-changes of the thermopile case. Several different exposures were necessary; (i) normal exposure for the principal line and strong satellites, the faint lines being mostly under-exposed; (ii) normal exposure for satellites of strong and medium intensity, the principal line being over-exposed; (iii) normal exposure for fainter lines. By successive comparisons of the different plates the relative intensities of the various satellites can be found. Sixty photographs were taken and six selected from these. Tables and diagrams are given showing the results obtained. A. W.

808. *Ritz Theory of the Normal Zeeman-effect.* **K. Körner.** (Deutsch. Phys. Gesell., Verh. 15. 3. pp. 69–74, Feb. 15, 1913.)—On this theory the Zeeman-effect is the result of the precessional motion of the Ritz oscillators round the direction of the external magnetic field. The author shows that the theory only holds if the angular velocity of the motion $\omega = -\frac{1}{2}(eH/mc)$, where e is the charge of an electron, m the mass, H the field, and c the velocity of light *in vacuo*. This follows from the theory of the top if we assume that the elementary magnets in the Ritz oscillators are rotating negative electrons. J. M.

809. *Longitudinal Zeeman-effect.* **L. de la Rive.** (Archives des Sciences, 34. pp. 489–521, Dec., 1912.)—Discusses certain details of the Zeeman-effect, such as the initial conditions in the case of rectilinear polarisation, and the equivalence of Biot-Savart's electrodynamic force and the composite centrifugal force of the electron. It is shown that the magnetic rotation of the plane of polarisation (Faraday-effect) can be explained without having recourse to circular polarisation. Also that natural light, considered as due to two elliptically polarised rays, accords with the Zeeman phenomenon. E. E. F.

810. *Chemical Production of Light.* **W. D. Bancroft.** (Frank. Inst., Journ. 175. pp. 129–149, Feb., 1913. Paper read before the 8th Internat. Congress of Applied Chemistry, N.Y., Sept., 1912.)—The author gives a summary of the present state of knowledge regarding the production of light, the conclusions arrived at being briefly as follows:—Photo-, thermo-, pyro-, electro-, kathodo-, anodo-, crystallo-, tribo-, and organo-luminescence are all cases of luminescence due to and accompanied by chemical action, and in some instances of kathodoluminescence it is possible to give the chemical reactions taking place. It is more correct to speak of the spectrum of a reaction than of the spectrum of a substance, and any marked change in a spectrum indicates the occurrence of a new reaction. The same bluish light is emitted when (1) sodium burns slowly in chlorine, (2) sodium chloride is fused, (3) sodium chloride is placed in the surface separating the oxidising and reducing zones of the Bunsen flame, (4) gaseous hydrogen chloride is supplied to a sodium flame, (5) sodium chloride is precipitated from aqueous solution by alcohol or hydrochloric acid, and (6) sodium chloride crystals are crushed. The light effect due to the change from chlorine as ion to undissociated sodium chloride seems at present to be negligible, but more accurate measurements will doubtless show the existence of such effect. Kathode rays excite the bluish luminescence in sodium chloride and canal rays the yellow luminescence. Under the influence of kathode rays, potassium iodide emits green light, part of which is probably due to the iodine; it seems possible also that the chlorine may be the cause of some of the white light observed with many chlorides. The experimental evidence is insufficient to show with certainty that the triboluminescence of potassium iodide is the same as the crystalloluminescence and the kathodoluminescence of this salt. All reactions tend to emit light, and do so if the reaction velocity is sufficiently high, and the critical reaction velocity necessary to the emission of light visible to the eye may be very different with different reactions. The intensity of the emitted light increases with increasing reaction velocity, but the quality of the light varies but slightly. The sulphates of sodium, lithium, potassium, zinc, etc., increase the luminescence of cadmium sulphate when exposed to kathode rays chiefly by increasing the rate at which cadmium oxide and sulphur trioxide combine. With the phosphorescent sulphides of zinc, calcium, strontium and barium, the reaction which emits light is one involving the so-called impurities, for example, the salts of Cu, Bi, or Mn. Theoretically it is possible to stimulate the reactions causing fluorescence by means other than light. T. H. P.

811. *Comparison of the Spectra of Fluorescent Röntgen Radiations.* **J. C. Chapman.** (Roy. Soc., Proc. Ser. A. 88. pp. 24–37, Jan. 29, 1913.)—It is known that there are two groups of elements, series K and L, which emit characteristic X-radiations when suitably excited, and that the penetrating powers of these two sets of radiations are of the same order. Further, the empirical equation $W_K = \frac{1}{2}(W_L - 48)$ has been found to connect the atomic weights W_K and W_L of two elements which, though in different groups, emit characteristic radiations that have the same absorption coefficient in Al. In the present paper further similarities between the two groups of radiations have been found, and the identity of the two kinds of radiation established. In the first experiments the absorptions of the various radiations of both groups in Cu, Ag, and Pt was determined. In all cases the results show that if radiations from different groups suffer the same absorption in Al, then they are equally absorbed in any other element. It will be seen from the above equation that Br and Bi, though in different groups, emit radiations of equal penetrating power. The intensity of the corpuscular radiation produced in tungsten and copper and the ionisation resulting in ethyl bromide and nickel carbonyl, when equal amounts of energy of the two radiations were absorbed in these various substances, were measured by special methods and found in each case to be independent of whether the radiator was Br or Bi. These results prove that the two spectra of radiations, Group K and Group L, are identical in their nature, and this suggests that the mechanism of production is the same although the elements emitting the radiation differ widely in atomic weight. E. M.

812. *Retardation of α-Particles by Metals.* **E. Marsden** and **H. Richardson.** (Phil. Mag. 25. pp. 184–193, Jan., 1913.)—It has been shown that the range of α-particles from a single product depends not only on the density of the material penetrated, but also on its chemical nature. Bragg has determined the amounts of various substances necessary to cut down the range of α-particles by 1 cm. in air, and has noticed that the weights per unit area necessary for different metals are approximately proportional to the square roots of their atomic weights. Taylor [see Abstract No. 1887 (1909)] has further shown that, for layers of material of atomic weight greater than the

average atomic weight of air, the air-equivalent decreases with decreasing velocity, or range, of the entering α-particles, while in the case of hydrogen whose atomic weight is less than that of air, the air-equivalent increases with decreasing velocity. In these experiments the ionisation method of measurement was adopted. The present apparatus consists essentially of a travelling microscope with a zinc-sulphide screen attached rigidly to the objective so as to be in focus. The source of α-particles is some radium emanation, and the metal foil whose air-equivalent is under investigation can be placed on a platform, adjusted to any required distance from the zinc sulphide screen, and the scintillations produced observed. The method adopted is to raise the microscope and attached screen until just out of range of the α-particles, (1) without, and (2) with, the foil in position. Curves are given which show that the variations of air-equivalent are quite considerable and specially noticeable for low ranges. In particular the variation of air value in the cases of Al and mica is almost entirely confined to the last 2 cm. of emergent range. It is shown that a curve can be plotted connecting mass per unit area and air-equivalent, and such curves are given for Au, Ag, and Al. A note is appended on an illumination of the screen when moved towards the source of particles just prior to the point where the scintillations begin to appear in large numbers on the screen.
A. E. G.

813. *Tracks of Single α-Particles on a Photographic Plate.* **W. Michl.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1431–1447, Oct., 1912.)—Kinoshita showed [Abstract No. 922 (1910)] that when an α-particle penetrates a halide grain of a photographic plate, the whole grain becomes capable of development. Reinganum later showed that the path of an α-particle in the emulsion could be traced by the track of silver grains on development. The author has repeated and extended Reinganum's work and made quantitative measurements of the length of the tracks and the number of grains contained when α-particles of different range are used. Thus with the particular emulsion employed an α-particle of polonium produces a track of average length 23 μ, and containing about 8 grains. Both the length of the track and the average number of grains were found to be linear functions of the range in air of the α-particles employed.
E. M.

814. *Ionisation produced by β- and γ-Rays at High Pressures.* **D. C. H. Florance.** (Phil. Mag. 25. pp. 172–183, Jan., 1913.)—The ionisation produced by γ-rays in a closed vessel is due partly to the β-rays escaping from the walls, and partly to the β-rays set up from the molecules of the gas. The author has made measurements of the ionisation due to γ-rays between two plates at various pressures up to 80 atmos., so as to completely absorb the secondary β-rays. In this way their absorption properties have been studied and compared with the results obtained with the primary β-rays of UrX deposited as a thin film on one of the plates. From the observations the apparent coefficient of absorption of the β-rays from UrX was calculated to be 0·04 cm.$^{-1}$ in air, although by a special arrangement this could be reduced to 0·007. In the case of the γ-rays from RaC, the secondary β-rays were found to have the same absorption properties, whatever material was used for the electrodes. The "emergent" β-rays were found to have an absorption coefficient of 0·046 cm.$^{-1}$ air, and the "incident" β-rays 0·056 cm.$^{-1}$ air. Thus the "emergent" β-rays are similar in penetrating power to the β-rays of UrX. With plates of Al 1 cm. apart the ionisation in the air between them

due to γ-rays passing normally through the plates was found to be negligible at atmospheric pressure, and approximately 25 % of the total ionisation at 80 atmos. E. M.

815. *β-Rays of Radium B, C, D, E.* **J. Danysz.** (Le Radium, 10. pp. 4–6, Jan., 1913.)—The paper deals with a redetermination of the velocities of the "bands" of β-particles in the "magnetic spectrum" [see Abstract No. 325 (1912)]. In the experimental arrangement the β-rays are made to describe a semicircle by the magnetic field before falling on a photographic plate placed parallel to the field. Values are given for 25 sets of β-particles from Ra (B + C), and it is shown that the same results are obtained whether an active Pt-wire is used or emanation contained in a thin-walled tube. The "magnetic spectrum" of Ra (D + E) shows four lines presumably due to RaD, together with a broad, diffuse band of higher velocity due to RaE. The four lines due to RaD appear to correspond to four lines due to RaB in that they have the same differences between their energies. Thus from Ra (B + C) there are 4 sets of β-particles whose energies $\times 10^{-13}/e$ are 0·366, 0·367, 0·492, and 0·522, while the energies of the RaD β-particles are $\times 10^{-13}/e$: 0·309, 0·311, 0·435, and 0·468. This seems to suggest that the differences in the energies are due to the same atomic mechanism [see Abstract No. 433 (1913)]. Photographs are given illustrating the results. E. M.

816. *Penetrating Power of γ-Rays from Radium C.* **A. S. Russell.** (Roy. Soc., Proc. Ser. A. 88. pp. 75–82, Jan. 29, 1913.)—The primary object of the experiments was to find out if there is any residual radiation from RaC after the γ-rays of ordinary penetrating power have been entirely absorbed. A γ-ray electroscope with walls of Pb 1 cm. thick was placed over an iron pot, of diam. 30 cm. and height 33 cm., which could be filled with Hg. A source of RaEm was placed near the bottom of the pot, and the absorption of the γ-rays determined by filling in different amounts of Hg. With the strong source used, 300 millicuries RaEm, no ionisation could be detected through more than 26 cm. Hg even when an ionisation vessel with air at a pressure of 80 atmos. was substituted for the electroscope. The results show that the γ-rays are absorbed over a range of thickness of 1 to 22·5 cm. strictly according to an exponential law with a value of $\mu/d = 4{\cdot}38 \times 10^{-2}$. Over this range the intensity is diminished in the ratio of 360,000 to 1. This value of μ/d is very near to that found previously for lead, *i.e.* $4{\cdot}37 \times 10^{-2}$ [Abstract No. 1252 (1910)]. The author concludes that if any ionising radiation exists more penetrating than γ-rays, then its intensity is less than 2×10^{-6} of that of the initial γ-ray beam. E. M.

817. *Excitation of γ-Rays by α-Rays.* **J. Chadwick.** (Phil. Mag. 25. pp. 193–197, Jan., 1913.)—In a previous paper the author has shown that β-rays of Ra impinging on matter produce γ-rays, and in the present experiments this result has been extended to α-rays. The source employed was RaEm with its active deposit enclosed in a thin-walled glass α-ray tube. This tube was surrounded by a tube of some material of low atomic weight, say Al, just thick enough to stop all the α-rays. Then round this was placed a similar tube of a metal of high atomic weight, say gold. The ionisation produced by the γ-rays emitted by the emanation tube under these conditions was measured by a balance method in an ionisation chamber containing methyl iodide or carbon disulphide, these gases increasing the ionisation due to soft excited γ-rays relative to the hard primary γ-rays. Taking the ionisation when the inner tube was Al as 100, the ionisation obtained with Au as the inner and Al as the outer tube was 104·8, with Ag 102·5, with Cu 101·2, and with paper 99·7. By an experiment with a magnetic field it was shown that these increased ionisations were not due to γ-rays excited by soft β-rays, but were due to γ-rays excited by the α-rays. The measurements indicated an absorption coefficient of about 8 cm.$^{-1}$ Al for the excited γ-rays. E. M.

818. *Asymmetric Emission of Secondary Rays.* **O. W. Richardson.** (Phil. Mag. 25. pp. 144–150, Jan., 1913.)—The experiments of Bragg and others have shown that when γ- or X-rays pass through a thin plate of matter the secondary radiation is much greater on the emergent than on the incident side. Further, Stuhlmann and Kleeman have shown that when thin films of metals are traversed normally by ultra-violet light, the number of electrons emitted on the emergent is greater than on the incident side. These results lead at first sight to the view that the energy of γ-, X-, or light-radiation is not uniformly distributed but exists in a very concentrated form in limited regions, so that a single electron may be made to receive the major part of both the energy and momentum in a radiation unit. In the present paper the author considers an explanation of the above effects without making any definite hypothesis about the structure of radiation. The consideration is based on Planck's idea that the transference of energy to an electron goes on in a manner which may be treated as continuous until there is a disruption when the energy of the electron is a simple integral multiple of $h\nu$, where ν is the frequency of the radiation and $h = 6{\cdot}55 \times 10^{-27}$ erg sec. The author further supposes that the act of disruption results in the liberation of an electron to such an extent that it no longer forms part of the dynamical system to which it originally belonged. In favourable cases, especially when ν is large, the electron may be expelled from the matter and appear as secondary radiation of the β or electronic type. Thus if $\bar{u}$ is the average component of velocity of the disrupted electrons in the direction of incidence of the radiation, v^2 the average value of the square of their velocity at the instant of disruption, c the velocity of light, the equation is deduced $\bar{u} = v^2/2c$. Thus the asymmetry of the secondary radiation should be more marked the greater the value of $\bar{u}/v$, and hence the greater the value of v. This is known to be the case. Further considerations are given, and the author concludes that some such theory as the foregoing must be reckoned with in explaining the effects. E. M.

819. *Radium E.* **R. Thaller.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1611–1628, Oct., 1912.)—The experiments were carried out to decide whether RaE is a single product or consists of two successive products. A plate was exposed to RaEm and the rate of growth of the RaE from the RaD was investigated, the results indicating that RaE consists of one product only. By electrolysing a solution of Ra (D + E) acetate varying amounts of RaD were found to be deposited with the RaE, according to the current density. In every case, after allowing for the residual activity of the RaD the decay of the RaE was found to be strictly exponential, showing again that it is not complex. The half-time period was determined to be 4·85 days. E. M.

820. *Heating Effect of Radium and its Emanation.* **E. Rutherford** and **H. Robinson.** (Phil. Mag. 25. pp. 312–330, Feb., 1913. Akad. Wiss. Wien, Ber. 121. 2a. pp. 1491–1516, Oct., 1912.)—The apparatus employed consisted of two differential Pt-resistance thermometers similar to those employed by Rutherford and Barnes. The heating effect of the emanation in a tube with

all its products to RaC was measured and then the emanation suddenly withdrawn. The rate of decrease of the heating effect due to the decay of the products was found to follow very accurately that of the decrease of the energy of the radiations. An estimate of the heating effect of the β- and γ-rays was obtained by surrounding a tube of emanation with cylinders of metal of various thicknesses. From the results the distribution of the heating effect between radium and its products and radiations is deduced to be :—

Substances.	Heating Effect in gm. cals. per hour corresponding to 1 gm. of Radium.			
	α-rays.	β-rays.	γ-rays.	Total.
Radium	25·1	—	—	25·1
Emanation	28·6	—	—	28·6
Radium A	30·5	—	—	30·5
Radium B Radium C	39·4	4·7	6·4	50·5
Totals	123·6	4·7	6·4	134·7

It follows that the total heating effect of 1 gm. of Ra for complete absorption of the α-, β- and γ-rays should be about 135 gm. cals. per hour on the Vienna standard. E. M.

821. *Comparative Absorption of γ- and X-rays.* **S. J. Allen** and **E. J. Lorentz.** (Phys. Rev. I. Ser. 2. pp. 35–49, Jan., 1913.)—The present paper is a continuation of previous experiments by Allen [Abstract No. 1038 (1912)] and deals with the softest γ-rays emitted from radium, and X-rays of various degrees of hardness. The authors succeeded in obtaining X-rays whose coefficient of absorption in Al was only four times that of the soft γ-rays. The absorption by a very large number of substances was examined. For the soft γ-rays, λ/d was found to follow the same general characteristics as previously found for the hard rays, but increasing with the atomic weight in a more rapid manner. For X-rays λ/d was also found to increase in general with the atomic weight, but with some substances, notably silver, anomalous results were obtained. These anomalous results appear to be connected with the fluorescent secondary X-radiation discovered by Barkla. No anomalous results were found for the very high weight atoms such as Pb and Pt. E. M.

822. *Emanation in Sea-water.* **J. Laub.** (Phys. Zeitschr. 14. pp. 81–83, Jan. 15, 1913.)—The amount of emanation in sea-water was measured at 15 points in the Atlantic, 4 in the Straits of Magellan, and 31 in the Pacific along the South American coast. The mean emanation-content was 0·14 Mache unit in the Atlantic, 0·09 in the Straits, and 0·08 in the Pacific. No systematic difference in the emanation-content could be traced to temperature or to distance from coast. E. E. F.

823. *Measurement of the Earth's Penetrating Radiation on Seven Balloon Ascensions.* **V. F. Hess.** (Phys. Zeitschr. 13. pp. 1084–1091, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)

HEAT.

824. *Mechanical Differential Telethermograph.* **L. J. Briggs.** (Washington Acad. Sci., Journ. 3. pp. 33–35, Jan. 19, 1913.)—This instrument consists essentially of two independent Bourdon spring systems, each hollow spring communicating with a copper bulb by means of a copper capillary. Each system is completely filled under pressure with a liquid having a high thermal expansion coefficient. These two systems are mounted in such a manner that the free ends of the springs move in the same plane and in opposite directions when the two systems undergo the same change in temperature. The free ends of the two Bourdon springs are connected in the plane of movement by a double link, the two members of which are approximately parallel and normal respectively to the paths traversed by the ends of the springs. The normal link is connected at its approximate centre to a second link which communicates with the pen mechanism. When the two systems undergo a simultaneous change in temperature, the free ends of the springs, in expanding or contracting, rotate about the centre of the connecting link without producing any translation of this point. No change occurs, therefore, in the position of the recording pen on the drum. When, however, a differential change in the temperature of the two systems occurs, a greater movement is produced in the free end of one Bourdon spring than in the other, and a corresponding movement of the pen-arm takes place. The instrument is thus designed to record differences in the temperature of the two systems, independent of the absolute temperature. To protect the working parts from changes of temperature, the instrument is provided with a metal cover blackened inside, and the interior is given an open construction. Applications of the apparatus to the recording of the depression in temperature of the wet-bulb thermometer, and of the changes in intensity of solar and sky radiation, are described. A. W.

825. *Conduction of Heat along a Pipe through which Gas flows; Relation to Experiments on Specific Heats of Gases.* **W. F. G. Swann.** (Phil. Mag. 25. pp. 109–115, Jan., 1913. Paper read before the British Assoc. at Dundee.)—The author determined some years ago the specific heats of air and CO_2 at constant pressure. His results have been confirmed by others [see Abstract No. 504 (1912)] and agree to 1 in 1000 with the theoretical values deduced from J. Joly's determinations at constant volume. They are, however, 2·5% higher than those of Regnault. The discrepancy seems to arise through an error in Regnault's correction for the heat lost by conduction along the pipe from the heater to calorimeter and for heat lost by radiation from the calorimeter. Regnault determined the constants in his correcting equation by noting the rate of temperature-increase in the calorimeter before and after gas had passed through it. The error lies in assuming that the constant for heat conduction is the same when the gas is, or is not, flowing. This is not so because the hot gas produces a different temperature gradient in the pipe. The author makes experiments to determine the error involved, and though the exact conditions of Regnault's experiments are not repeated, the error determined is extremely near in value to the discrepancy to be explained. H. S. R.

826. *Thermostat for Low Temperatures.* **F. Henning.** (Zeitschr. Instrumentenk. 33. pp. 33–38, Feb., 1913. Communication from the Physikal.-Techn. Reichsanstalt.)—The author describes a thermostat for use at low temperatures (0° to −150°) which allows a constancy of temperature within a few hundredths of a degree. The apparatus employed cannot briefly be described, but the principle on which it depends is the cooling of a liquid (alcohol or petroleum ether) by means of liquid air. A. F.

827. *Specific Heats of Helium and some Diatomic Gases between +20° and −180°.* **K. Scheel** and **W. Heuse.** (Preuss. Akad. Wiss. Berlin, Ber. 2. pp. 44–48, 1913. Communication from the Physikal.-Techn. Reichsanstalt. Ann. d. Physik, 40. 3. pp. 473–492, March 20, 1913.)—The authors make use of the method described previously [Abstract No. 504 (1912)], except that the apparatus was so modified that a closed circuit was formed for the circulation of the gas, so that rare or poisonous gases could be investigated. The results obtained are given in the following table, where the symbols used have the ordinary signification, those marked with 0, for example k_0, being the values calculated for the ideal gas state. The values for constant volume were calculated from the experimental numbers for constant pressure by means of expressions deduced by a combination of the ordinary thermodynamical equations with D. Berthelot's equation of condition.

Temp.	C_p in watt.-secs. per gm. degree.	C_p in gm. cals.$_{15}$ per gm. degree.	C_p.	C_v.	C_{p_0}.	C_{v_0}.	k.	k_0.
				Helium.				
+ 18	5·278	$1{\cdot}26_0$	4·993	3·008	4·993	3·008	1·660	1·660
− 180	5·22	$1{\cdot}24_5$	4·934	2·949	4·934	2·949	1·673	1·673
				Hydrogen.				
+ 16	14·26	3·403	6·860	4·875	6·860	4·875	1·407	1·407
− 76	13·23	3·157	6·365	4·379	6·364	4·379	1·453	1·453
− 181	11·08	2·644	5·330	3·338	5·320	3·335	1·597	1·595
				Nitrogen.				
+ 20	1·044	$0{\cdot}249_2$	6·983	4·989	6·969	4·984	1·400	1·398
− 181	1·071	$0{\cdot}255_6$	7·162	4·879	6·718	4·733	1·468	1·419
				Oxygen.				
+ 20	0·914	$0{\cdot}218_2$	$6{\cdot}98_2$	$4{\cdot}98_9$	$6{\cdot}97_0$	4·985	1·399	1·398
− 76	0·898	0·214	6·86	4·84	6·81	4·83	1·416	1·411
− 181	0·956	0·228	7·30	5·04	6·90	4·91	1·447	1·404
				Air (free from CO_2).				
+ 20	1·008	$0{\cdot}240_6$	6·965	4·972	6·953	4·968	1·401	1·400
− 76	1·018	$0{\cdot}243_0$	7·04	5·02	6·99	5·01	1·401	1·396
− 181	1·046	$0{\cdot}249_6$	7·23	4·99	6·85	4·86	1·450	1·408
				Carbon Monoxide.				
+ 18	1·048	$0{\cdot}250_2$	7·006	5·011	6·991	5·006	1·398	1·396
− 180	1·084	$0{\cdot}258_7$	7·244	4·922	6·743	4·758	1·472	1·417

T. S. P.

828. *Method of obtaining Sublimates.* **A. L. Fletcher.** (Roy. Dublin Soc., Proc. 13. 32. pp. 460–466, Feb., 1913.)—A modification of Joly's meldometer, consisting of an electrically heated carbon rod (or Pt strip) sublimes the sample on to a cover plate of glass, silica, biscuit, etc. A few mgm. are usually sufficient. About 3×10^{-7} gm. of arsenious oxide or lead oxide has in this way been appreciable, and about 10^{-6} gm. of arsenic could just be identified. Various results are given showing the type of sublimates with a glass plate held near to or away from the sample, and by sublimation in H_2S, and upon an iodine sublimate. Alloys and steel may be fractionally sublimed, and small quantities of impurities have been qualitatively detected. F. R.

829. *Theory of Black Radiation.* **M. Brillouin.** (Comptes Rendus, 156. pp. 124–126, Jan. 13, 1913.)—From one of the last memoirs of Poincaré the hypothesis of "quanta" is an inevitable consequence of experiment if we suppose that the resonators by which we represent emissive and absorbing matter are rigorously monochromatic. This latter supposition seems to possess an excessive mathematical simplicity, which nothing will justify from an experimental standpoint. It is therefore of interest to examine the consequences of abandoning it. In the present paper the author considers a system formed of an electron revolving round a central mass, and, with the different conditions stated, shows that the total energy of the resonators in which the same period τ is established form a discontinuous sequence corresponding to the successive values of the integer n. The method of obtaining all frequencies by means of a single type of vibrating system, by variation of the energy of oscillation, is more satisfactory than the hypothesis of an infinity of monochromatic vibrators. The law of black radiation should be connected directly with the law of energy $E(r)$ as a function of the distance r of the electron, and could serve to determine this function. But, to make this clear, it would be necessary to consider the relations of the vibrating body with the ether. A. W.

830. *Atomic Theories of Radiation.* **R. A. Millikan.** (Science, 37. pp. 119–133, Jan. 24, 1913. Paper read before Section B of the Amer. Assoc. for Advancement of Science.)—The last fifteen years have shown the atomic and kinetic conceptions to be the most fruitful which have ever been introduced into physical science. Only in one domain have atomistic points of view failed to possess the field completely, and that the only domain in which they were securely entrenched two hundred years ago, but from which they were driven, apparently for ever, at the beginning of the last century, by the epoch-making work of Fresnel and Young. Upon this lost domain of *radiant energy* they are now making renewed attack. The present paper surveys this field of conflict and endeavours to appraise the successes and failures of each of the opposing forces from the point of view of *experimental* physics alone.

In this attack upon the domain of radiant energy, atomistic conceptions do not at present show a united front. There is not one sharply-defined atomistic theory, but there are five distinct brands of *quantum* theory of various degrees of concentration. These are alike in that they have to do with certain assumptions as to the nature of radiant energy, or as to the conditions under which such energy is absorbed or emitted by atomic or sub-atomic oscillators. The various theories are then discussed with special reference to the experimental facts which have called the five different types of assumption into being.

1. The first and least concentrated form, that of Planck, grew out of the fact that we had two radiation formulæ—(1) that of Rayleigh, and (2) that of Wien; the first of which fitted the experimental facts for long wave-lengths (for which alone it was indeed suggested), while the second fitted the experimental curve at the other end of the spectrum only, although it was

originally hoped that it would give the correct distribution of energy throughout the spectrum. Wien's general formula had been deduced from his displacement equation (an equation which rests only on thermodynamic reasoning and the proved facts of radiation pressure) with the aid of two additional assumptions, viz., (1) that the velocities of gas molecules follow the Maxwell distribution law, and (2) that the frequency of the vibrations sent out from a given molecule depends only on the temperature. Since this equation failed at long wave-lengths, and yet contained no more *particular* assumptions than those just mentioned, and since the first of these assumptions is one which we have the best of grounds for making, there was nothing to do but modify the last one. Planck modified it in such a way as to obtain an equation that would go over into Rayleigh's equation at long wave-lengths, and into Wien's at short wave-lengths. Planck's own argument is briefly somewhat thus. Boltzmann's identification of the concept of entropy in thermodynamics with the concept of probability in statistical mechanics (a step which Planck calls the "emancipation of the entropy concept from the limitations of man's experimental skill, and the elevation of the second law to a real principle") carries with it as a necessity not only the atomistic conception of matter, but also some sort of an atomistic conception of radiant energy. For the assigning of an exact numerical value to the probability of a given physical condition can be accomplished only by considering that condition as dependent on a finite number of equally likely possibilities or complexions. The greater the number of these complexions, the greater the value of the probability. Thus with two dice the probability of a four-dot throw is just three times that of a two-dot throw, because the former may occur in three equally likely ways or complexions, and the latter in only one. Now when the entropy of a physical condition is made to depend in this way on the probability of its occurrence, it may be seen at once that entropy tends toward a maximum simply because a change to a new state will not take place unless that new state has a greater probability than the old one. But, says Planck, there is no way of making the appearance of a given physical condition in a system depend in this way upon a definite, countable number of possibilities, except by conceiving the system to be made up of a definite number of concrete and definite elements, for a continuum cannot have countable elements. Hence, an atomistic structure of the system is a fundamental condition for the representation of its entropy by a probability. All systems, then, which possess an entropy must possess an atomic structure. Now experiment justifies the carrying over of the entropy concept to an enclosure filled with radiant energy, for it is only in this way that the Stefan-Boltzmann law and the Wien displacement law (both of which are found experimentally to be correct) are deduced. Hence we are forced to conclude that an atomistic structure of some sort must be applied to radiant energy. Planck then proceeds to apply it as follows. He imagines an enclosure having perfectly reflecting walls to be filled with black-body radiation. In this enclosure, and in equilibrium with the black-body radiation, are linear electromagnetic oscillators of a given frequency ν. The relation between the energy U_ν in each oscillator of frequency ν, and the energy per unit volume u_ν of black-body radiation of frequency ν, is given by the ordinary electrodynamic laws as $U_\nu = (c^3/8\pi\nu^2)u$, in which c represents the velocity of light. The idea of *atoms of energy* is next called in, and it is assumed that each oscillator contains at each instant an exact multiple of an element of energy ϵ. From a consideration then of the total number of oscillators, and the total number of energy elements in all the oscillators, we can obtain an expression, as in the case of the dice, for the total number of complexions of the system, that is, the total number of possible distributions of the energy elements among the oscillators. This leads to an expression for the entropy of the system of the form $S = F(U/\epsilon)$. But the second law of thermodynamics as applied by Wien [Wied. Ann. 52. p. 182, 1894], had shown that $S = F(U/\nu)$. Hence we must place $\epsilon = h\nu$, that is, the energy element ϵ is proportional to the natural frequency ν of the oscillator, and the proportionality factor h is a universal constant, which Planck calls the *Wirkungsquantum*. He thus arrives at this celebrated formula for the relation between the density of black-body radiation and frequency, viz. :—

$$u_\nu = \frac{8\pi h\nu^3}{c^3} \cdot \frac{1}{e^{h\nu/ckT} - 1},$$

or, the intensity E_λ of black-body radiation of wave-length λ_1 and temperature T_1 is $E_\lambda = 2c^2h/(\lambda^5 e^{ch/k\lambda T} - 1)$.

This formula meets the requirements of passing over, at small values of λT, into Wien's equation, namely, $E_\lambda = (2c^2h/\lambda^5)e^{-ch/k\lambda T}$, and for large values of λT, into Rayleigh's equation, viz. $E_\lambda = 2ckT/\lambda^4$. Planck finds a further proof of the necessity of taking some such steps as that which he has taken in the faultlessness of Jeans's logic in showing that the Hamiltonian equations, combined with the theory of probability, lead inevitably to Rayleigh's radiation equation, which is contradicted by experiment. There is then, in his judgment, nothing whatever to do except to deny the general validity of the Hamiltonian differential equations, and this is precisely what he has done. Furthermore, the fact that his own equation goes over into Rayleigh's equation when h is made infinitely small seems to him to show decisively that certain elementary radiation processes which in Jeans's theory are assumed to be continuous are in fact discontinuous.

During 1912 Planck modified his theory to meet an objection put forward by Poincaré as to the profound revolution of physics which would be involved by the assumption that physical phenomena do not obey laws expressible by differential equations. Planck's original theory implied that both absorption and emission of energy by the oscillator must take place in units—that is, discontinuously. Planck's modified idea is that emission alone takes place discontinuously, while the absorption process is continuous. At the instant at which a quantity of energy $h\nu$ has been absorbed an oscillator has a chance of emitting the whole of its unit—a chance which, however, it does not necessarily take. If it in this way misses fire it has no other chance until the absorbed energy has arisen to $2h\nu$, when it has again the chance of throwing out its two whole units, but nothing less. If again it misses fire its energy rises to $3h\nu$, $4h\nu$, etc. The ratio between the chance of not emitting when crossing a multiple of $h\nu$, and the chance of emitting, is assumed to be proportional to the intensity of the radiation which is falling upon the oscillator.

This, then, is at present the most fundamental and the least revolutionary form of quantum theory, since it modifies classical theory only in the assumption of discontinuities in *time*, but not in *space*, in the emission (not in the absorption) of radiant energy.

2. The second of these theories is somewhat more radical than that just noticed ; it is, in fact, merely that originally proposed by Planck. Despite the fact that Planck has renounced this point of view, the theory refuses to die. Nernst and most of the investigators who are working in specific-heat relations still adhere to it. What is the experimental situation which seems

to demand it? It is that brought about by the recent development of methods of studying specific heats at high and low temperatures, especially the liquefactions of hydrogen and helium.

3. We now come to forms of atomistic theory which make radical assumptions regarding the distribution of radiant energy in *space* rather than in *time*. The least radical of these, because the least general, is that of which Bragg is the most active exponent. It is frankly corpuscular. It was developed, however, with a view of explaining the properties of one type of radiation only, namely, X-rays and γ-rays, and at a time when there was some justification for regarding these as isolated phenomena.

4. A general hypothesis was made by J. J. Thomson in his Silliman lectures in 1903. It was, historically, the first form of the modern atomistic theories of radiation as regards space relations, although it is here treated in the fourth place, because it is considered to stand fourth in the violence of the assumptions involved. Like Bragg's theory, it postulates radiant energy which is emitted by the source in bundles or quanta, though no necessary multiple relationship was at first assumed between the different elements emitted by the same source. It goes farther than Bragg's theory in endeavouring to reconcile this quantum notion with the wave theory by assuming a fibrous structure in the ether and picturing all electromagnetic energy as travelling along Faraday lines of force conceived as actual strings extending through all space. To the support of such an hypothesis are brought all the arguments urged for Bragg's theory, while the arguments which the present author urges against Bragg's theory are removed.

5. The most concentrated form of quantum hypothesis is that proposed by Einstein in 1905 [Abstract No. 1562 (1905)]. It is simply the J. J. Thomson theory of the discontinuous distribution of radiant energy in space, assumed still to be electromagnetic, and hence to have a velocity independent of that of the source, with the addition of Planck's original assumption that a given source emits and absorbs energy in units which are multiples of $h\nu$.

Reviewing the experimental data, the author recognises two main results which stand out conspicuously. (1) Neither atoms nor electrons appear to be able to absorb any energy until it comes to them in a certain degree of intensity, and this degree varies with different substances. (2) In all types of experiments in which the absorption of energy results in the emission of electrons there is apparently a complete, or nearly complete, inter-convertibility of energy between an electron and a so-called ether ray, whether it be an X-ray or a light ray.

One group of theorists focus attention on one of the above results, another on the other. The fifth and last of the quantum theories is designed to cover both groups of facts which are obviously most completely interpreted in terms of such a theory, however radical it may be. Why not adopt it? Simply because no one has thus far seen any way of *reconciling* such a theory with the facts of *diffraction* and *interference* so completely in harmony in every particular with the old theory of ether waves. The author leaves the point at issue undecided. E. H. B.

831. *Method of obtaining p-T-Lines for constructing Diagrams of State.* **G. Tammann.** (Gesell. Wiss. Göttingen, Nachr., Math.-phys. Klasse, 7. pp. 790–802, 1912.)—For temperature-regions in which it is difficult to maintain a constant temperature (above 100° and below 0°), the measurement of the equilibrium pressures at constant temperature may be replaced by a method depending on the simultaneous observation of pressure and tempera-

ture during the heating of the substance under investigation. As regards the external conditions, two principal cases are to be distinguished : (1) the substance is kept at constant volume ; (2) this is not the case, so that the volume alters with p and T. From the p-T-curves the equilibrium (melting and transformation) curves may be readily constructed, and, with the aid of these curves and of the compressibility, the changes of volume, Δv, during change of state under constant temperature or constant pressure are easily derivable. Further, from Δv and the direction of the equilibrium curve (dT/dp), the heats of fusion for different pressures can be calculated. This procedure may be applied, not only to individual substances, but also to systems of two or more components. The above relations are worked out mathematically.

T. H. P.

832. *Adiabatic Increase of Entropy.* **P. Duhem.** (Comptes Rendus, 156. pp. 284–286, Jan. 27, 1913.)—The author critically examines the general proposition that "if a system is enclosed in an envelope impermeable to heat, every modification accompanied by viscous work entails an increase of entropy." Although nobody has called the proposition into question, the author treats the subject rigidly from the standpoint of established laws.

H. H. Ho.

833. *On the Elements of Energy.* **J. Duclaux.** (Comptes Rendus, 156. pp. 142–144, Jan. 13, 1913.)—According to the rule of Pictet and Trouton, the quotient ML/T is approximately a constant for different liquids ; likewise the quotient Q/T, where Q is the heat of dissociation of a substance, is also approximately the same for different substances. We are therefore led to the conclusion that when a union between atoms or between molecules is broken in a reversible manner at the absolute temperature T, a quantity kT of heat is absorbed, k being a constant (equal to 21) independent of the nature of the union. The author calculates the heat (or energy) required to rupture a single bond, and finds the value to be $\epsilon = 9{\cdot}5 \times 10^{-16}\,T$, measured in ergs. This "element of energy" is the smallest quantity of energy concerned in a chemical transformation or in a change of state at the temperature T. When we compare this element of energy with that of Planck, which is the smallest quantity of energy which can take part in a radiation of the wave-length λ, a very close agreement is found between the two numbers. The author points out that if the values are really identical, the quanta hypothesis of Planck becomes simply a new form of the Pictet-Trouton rule.

A. F.

834. *Statistical Theory of Radiation.* **K. F. Herzfeld.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1449–1468, Oct., 1912.)—Mathematical treatment.

E. H. B.

835. *Canonical Equation of Condition of Solids and the Quanta Theory.* **K. Eisenmann.** (Ann. d. Physik, 39. 6. pp. 1165–1174, Dec. 23, 1912.)—Shows that on the basis of the theory of quanta a complete derivation of the energy and of the equation of condition of a solid body can be given after introducing a distribution function.

E. E. F.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

836. *Electromotive Force of Accelerated Conductors.* **R. C. Tolman.** (Science, 37. pp. 192–193, Jan. 31, 1913.)—The possibility that electromotive forces might be produced by the mechanical acceleration of electric conductors was first thoroughly considered by Maxwell (Treatise on Magnetism and Electricity, vol. ii. 211, etc., 3rd Edition), and the actual presence of such electromotive forces in electrolytic conductors was shown by Colley in 1882 (Wied. Ann. 17. p. 55, 1882). The author's experiments have so far shown that the effect in metals, if existent, is smaller than in electrolytes. The apparatus is now being improved with the hope of detecting the effect in metals. E. H. B.

837. *Charge of Photoelectric Electrons.* **E. Alberti.** (Ann. d. Physik, 39. 6. pp. 1133–1164, Dec. 23, 1912. Extract from Dissertation, Berlin.)—The specific charge of photoelectric electrons has been roughly determined by Lenard [Abstract No. 1845 (1900)] and Thomson [Abstract No. 1294 (1900)]. The rays composed of these electrons are very homogeneous, of velocity negligible in comparison with that due to 10,000 volts, and obtainable in the highest vacuum. On the other hand, the electron current is small and the phosphorescence feeble. The author used a mercury-vapour lamp, quartz lenses, and a copper kathode. The rays, accelerated by an electric field, and deflected by a magnetic field, cast the shadows of copper wires on to a screen of Sidot blende. The mean value of 129 observations for the specific charge e/m is $1{\cdot}756 \times 10^7$ in good agreement with previous values. E. E. F.

838. *Some Electron Orbits.* **C. G. Darwin.** (Phil. Mag. 25. pp. 201–210, Feb., 1913.)—In order to find the characteristics of such processes as the absorption by matter of β- and kathode-rays, it is necessary to have a knowledge of the orbits of the electrons as they pass the various charged bodies in matter. According to Rutherford's theory [see Abstract No. 1347 (1911)], which is strongly supported by experiments, an atom is composed of electrons and a nucleus of positive electricity of charge such as to neutralise them. The nucleus is seated at the centre of the atom, bears nearly the whole mass, and has its charge concentrated inside a very small region. The present paper is concerned with the orbit of a β-particle as it passes such a nucleus. On account of its high velocity, a β-particle has apparent mass sensibly greater than that of a slow-moving electron, and during the path the attractive force of the nucleus still further increases it. The variability of mass entirely alters the character of the orbit, with the result that in certain cases it becomes a spiral, going right in to the centre. Numerical calculation shows that these cases should be of fairly frequent occurrence. The physical reason for this may be seen in the following way. On account of the increased mass the particle, when near the nucleus, will be moving slower than it would be if its mass were constant. This gives the attractive force more time in which to exert its effect, and analysis shows that in some cases the particle is unable to escape. The problem is then worked out mathematically on the basis of Lorentz's deformable electron. E. H. B.

839. *Speed of Electrons in Photoelectric Effect, as Function of the Light Wave-lengths.* **D. W. Cornelius.** (Phys. Rev. 1. Ser. 2. pp. 16–34, Jan., 1913.)—The chief results of this experimental research are as follows :—(1) A small amount of residual gas in the photoelectric cell influences its behaviour. (2) The surface conditions of the alkali metal has a very large influence upon the photoelectric effect; which may be constant or increase or decrease with time. (3) It usually requires time for a cell to reach a steady state of sensibility. (4) The attempts to measure the speeds of the electrons by means of the magnetic deflection have been unsuccessful. (5) The results obtained indicate that the equilibrium potential depends to some extent on the temperature of the metal if above 0° C. (6) The relation of the speed of the electrons and the frequency of the incident light is the same for : a pure potassium, potassium "fixed" with hydrogen, caesium, and caesium "fixed" with hydrogen. And the relation between the equilibrium potential and the frequency of the incident light is the more constant the nearer the metal approaches the permanent state of sensitiveness. (7) The theoretical and calculated values of the initial speed of the electrons are both of the order of 10^7 cm. per sec. (8) The theoretical value of the time needed for the expulsion of an electron due to the resonance effect of the incident light is of the order of 10^{-7} second. (9) The equilibrium potential of the electrons in the photoelectric effect varies directly as the square of the frequency of the incident light. Planck's law, according to which the units of the electromagnetic energy are proportional to the frequency is not confirmed. (10) While the theory of resonance shows that a beam of light may supply a sufficient amount of energy for the electron to escape, it cannot satisfactorily account for the essential fact that the speed of the electrons escaping from the metal is proportional to the frequency. [See Abstract No. 1201 (1911).]
E. H. B.

840. *Brownian Motions in Gases at Low Pressures.* **R. A. Millikan.** (Le Radium, 10. pp. 15–16, Jan., 1913. Phys. Rev. 1. Ser. 2. pp. 218–221, March, 1913.)—The mean Brownian displacement is shown to be expressed by—

$$D = \sqrt{\frac{4}{\pi} \frac{RT(v_1 + v_2)_1 t}{E(Ne)}}$$

where R is the gas constant, T the absolute temperature, E the electric field, N the number of molecules in a gm.-mol., e the electronic charge, $(v_1 + v_2)_1$ the greatest common divisor of the series of values estimated from the sum of the velocities $(v_1 + v_2)$ when the oil droplet modifies its charge by the capture of ions. From this and the experimental data it is calculated that $e = 4{\cdot}772 \times 10^{-}$.
E. H. B.

841. *Variation of Electronic Mass.* **J. Kunz.** (Archives des Sciences, 35. pp. 28–39, Jan. 15, 1913.)—A mathematical determination of the variation of the mass of an electron as a function of its velocity.
E. H. B.

842. *Electrification by Spraying Liqiuds.* II. **C. Christiansen.** (Ann. d. Physik, 40. 2. pp. 233–248, Feb. 4, 1913.)—A continuation of a previous article [see Abstract No. 468 (1913)]. The present paper deals with experiments chiefly on organic compounds, the results occupying over thirty tables.
E. H. B.

843. *Stokes' Law of Falling Drops and Electronic Charge.* **A. Schidlof** and [Miss] **J. Murzynowska.** (Comptes Rendus, 156. pp. 304–307,

Jan. 27, 1913.)—An application of Cunningham's correction to Stokes' law is used in dealing with new observations of falling drops. The mean value deduced is $e_0 = 4{\cdot}738 \times 10^{-10}$ in good agreement with the latest results of Millikan. [See Abstract No. 477 (1913).] E. H. B.

844. *Electric Dust-figures on Electrophorus Plate.* **G. Quincke.** (Deutsch. Phys. Gesell., Verh. 15. 4. pp. 96–101, Feb. 28, 1913.)—The author places a hollow metal hemisphere on the plate of an electrophorus, and near it he places a prism or biprism of conducting or insulating material with the edge vertical. He charges the hemisphere by a spark from a Leyden jar; then removes it without discharging it and sprinkles on the plate a mixture of sulphur powder and red lead. He describes the figures thus obtained and how the lines passing from the charged body behave on the further side of the prism or biprism. There is a considerable difference in the figures according as the body is charged positively or negatively. The author explains the formation of the various figures by a reference to his theory of the "foam-structure" of matter [see, for instance, Abstract No. 1523 (1906)]. T. P. B.

845. *Rectilinear Motion of Born's Rigid Electrons.* **W. Behrens** and **E. Hecke.** (Gesell. Wiss. Göttingen, Nachr., Math.-phys.-Klasse, 7. pp. 849–860, 1912.)—Mathematical treatment showing that under certain limitations the motion of an electron can be determined from its initial position and velocity. E. H. B.

DISCHARGE AND OSCILLATIONS.

846. *The Acetylene-Electric Flame.* **C. F. Lorenz.** (Electrical World, 61. pp. 511–515, March 8, 1913.)—When a powerful electric field is applied at right angles to a gas flame, the flame is deflected towards the kathode. There is no deflection until the anode is inside the invisible vapour mantle surrounding the flame, and the deflection is accompanied by a small current through the flame. The deflection is due to the greater potential drop at the kathode, brought about by the greater mobility of the negative carriers. If a heavy current is passed, the action at the kathode is confined to one spot, which is heated sufficiently to emit ions copiously, and then the deflection ceases. If an arc discharge is passed at right angles to a flame carrying a large proportion of free carbon there is a great increase in the luminosity of the flame. Acetylene is found to be a convenient illuminant, and curves are given showing the increased c.p. and the watts consumed. Direct current is more efficient than alternating, but the watt consumption for the increased c.p. is high. It is suggested that this type of flame is an efficient source of ultra-violet light [see Abstract No. 285 (1907)]. T. P. B.

847. *Mobility of the Positive Ion at Low Pressures.* **G. W. Todd.** (Phil. Mag. 25. pp. 163–171, Jan., 1913.)—In a previous paper [Abstract No. 368 (1912)] the author has shown that the mobility of the positive ion in gases at low pressures departs from the inverse pressure law, but at pressures much lower than is the case with negative ions. In the present paper further measurements have been made using the alternating field method as before. Owing to the fact that the dimensions of the measuring apparatus became of the order of about fifty free paths of the gas molecules at the lowest pressures in the previous experiments, it was impossible to draw definite conclusions as to the mass of the carrier from measurements of the mobility; consequently an apparatus was used on which the ions were made to oscillate over a much larger distance, *i.e.* 20 cm. By a special arrangement it was ensured that the field over this large distance was uniform at any instant. The positive ions were supplied by heated aluminium phosphate and the measurement of the mobility made by plotting the current in the electroscope for various values of the alternating potential. The results show the deviations of the mobility from the inverse pressure law to be much less marked than in the case when a smaller chamber was used. Further, the apparent mobility at a given pressure was found to increase largely with increasing frequency of the electric field. These results point to the conclusion that the positive ion, like the negative ion, has to travel a very considerable number of molecular free paths before an equilibrium state of ionisation exists. If the distance over which the mobility is measured is small and the source near one boundary of this distance, the proportion of ions reaching the other boundary as aggregates of gas molecules will be smaller than if the distance had been sufficiently large for equilibrium to have been reached. The experimental results lend some support to Kleeman's idea of a continually changing ionic aggregate. E. M.

848. *Recombination of Ions produced by Röntgen Rays.* **S. J. Plimpton.** (Phil. Mag. 25. pp. 65–81, Jan., 1913. Amer. Journ. Sci. 35. pp. 39–53, Jan., 1913.)—The method employed in the experiments consists essentially in ionising the gas between two parallel-plate electrodes as uniformly as possible by means of a single flash from a Röntgen-ray bulb, allowing the ions thus produced to recombine in the absence of any external field for small intervals of time regulated mechanically, and, by the sudden application of a strong electric field, driving over to the electrodes those ions which remain in the gas. The arrangement was such that the intensity of the flash of X-rays could be reproduced accurately, and in this way a series of relative values of n, the number of ions present at time t after the flash, which was of about 0·003 sec. duration, were obtained. The values of α, the coefficient of recombination [$dn/dt=\alpha n^2$] were deduced from the curve connecting $1/n$ and t, since $\alpha=d(1/n)/dt$. For all the gases examined: air, CO_2, SO_2, CH_3I, $(C_2H_5)_2$, C_2H_5Cl, C_2H_5Br, $(C_2H_5)_2O$, for short intervals of time up to about 0·3 sec. a marked curvature was found in the curves connecting $1/n$ and t, indicating that α is relatively large for the initial stages of recombination, but diminishes later, becoming practically constant. The author explains this effect on the assumption of a non-uniform distribution of the ionisation produced by Röntgen rays, the final values of α corresponding to an effectively uniform distribution. The experiments also show that the value of α decreases considerably with decreasing pressure of the gases examined. E. M.

849. *Ionisation by Röntgen Rays.* **F. Lebeau.** (Journ. de Physique, 3. Ser. 5. pp. 111–123, Feb., 1913.)—E. Meyer has shown [see Abstract No. 1198 (1912)] that the current produced in an ionisation chamber by a bundle of γ-rays emitted from Ra varies irregularly, about a certain mean value, in course of time. In the present experiments it is attempted to obtain with Röntgen rays fluctuations proceeding from the variation in the number of molecules ionised by a bundle of constant intensity. It is possible to obtain induction coil discharges of a uniform character. The bundle of Röntgen rays produced by the passage of a single one of such discharges always sets free in a given ionisation chamber the same quantity of electricity. By diminishing sufficiently the number of ions produced it might be possible to put in evidence fluctuations in this number of ions about a mean value. In order to be able to show such small deviations from the mean value, it becomes necessary to multiply the initial number of ions by ionisation due to collision, in some such manner as was employed by Rutherford for α-rays. The experimental arrangement with details of the observations is given in the following cases: When the direction of the rays is parallel to the plane of the electrodes, (*a*) without striking, (*b*) with striking; and when the rays are normal to the electrode. The fluctuations in the ionisation due to secondary kathodic rays produced by Röntgen rays striking the electrodes laterally or normally are shown to exist. The mean fluctuation increases when the multiplication by ionisation due to collision increases. In a particular case very large regular discontinuities have been obtained. An augmentation of the current takes place under the influence of successive rapidly repeated discharges. This augmentation, at least in the region of the critical pressure, seems to proceed from an action exercised by the Röntgen rays upon the gaseous molecules, which are thus rendered more susceptible to ionisation by collision. When the direction of the rays is normal to the electrodes, there occur from time to time extraordinarily large variations among discharges giving regular deviations. The process of ionisation for such strong discharges appears to be localised at the surface of the brass plate acting as insulated electrode. A. E. G.

850. *Photoelectric Behaviour of Iron in Active and Passive State.* **H. S. Allen.** (Roy. Soc., Proc. Ser. A. 88. pp. 70–74, Jan. 29, 1913.)—It is well known that ordinary iron, which is acted on energetically by dilute HNO_3 can be made to assume a passive condition by immersion in strong HNO_3 or by other powerful oxidising agents. The author has compared the photoelectric activity of iron in the active state with that of the same sample in the passive state, dry iron plates being used in each case. The photoelectric activity measured was that due to the light from a Hg lamp. The experiments prove that iron which is chemically active is active in the photoelectric sense, while iron which is passive shows much smaller photoelectric activity—in some cases none that can be detected. The author holds that this result is in good agreement with the theory which attributes passivity to the condition of the gaseous layer at the surface of the metal. E. M.

851. *Photography of Particles ejected from Atoms.* **C. T. R. Wilson.** (Engineering, 95. pp. 362–364, March 14, 1913. Paper read before the Royal Inst., April 11, 1913.)—By aid of Röntgen rays electrons may be ejected from ordinary atoms. The methods used in the study of electrons were usually indirect. But even electrons, when ejected, left trails behind them, and these the author has been able to photograph. Each electron ejected traversed a large number of gas atoms. But each such atom, on modern theories, is a miniature solar system, the planets being represented by electrons, which were held together by electrical instead of gravitational forces. When a disturbance of sufficient violence was set up, an electron might escape from one system and might become attached to another system. Now molecules of gases or vapours would more readily attach themselves to charged ions than to uncharged atoms, and every ion could be made a centre of condensation in supersaturated water-vapour. The author by aid of his *cloud-chamber* can now catch the ions in the positions occupied by them when just set free. The trail of a particle, invisible in itself, is thus marked by a crowded line of cloud, and individual ions could be distinguished under certain conditions. Nine photographs taken in this way are included in the paper as well as three diagrams explanatory of the experimental methods adopted. E. H. B.

852. *Positive Ionisation produced by Platinum and Certain Salts when Heated.* **F. Horton.** (Roy. Soc., Proc. Ser. A. 88. pp. 117–146, Feb. 24, 1913.)—Spectroscopic investigation of the nature of the carriers of positive electricity when an electric current is sent from a glowing Pt strip covered with aluminium phosphate to a surrounding Pt electrode in a highly evacuated vessel, shows that CO gas is evolved, and is probably the carrier of positive electricity. Hydrogen was also detected, and it seems probable that atoms of hydrogen also take part in carrying the current, for Garrett [see Abstract No. 117 (1911)] has found that about 10% of the positive ions present when aluminium phosphate is heated on a Pt strip in a vacuum have a mass corresponding to that of the hydrogen atom. Richardson, however, has come to the conclusion that the positive ions emitted by heated salts are charged atoms of the metallic constituent of the salt under test, and that in the case of the incandescent metals the carriers of positive electricity are charged atoms of Na or K which are present as impurities in the form of salts. It is in order to obtain further evidence on this matter that the experiments described in the present paper are undertaken. The general method is as follows :—The positive leak from a strip of Pt-foil is first investigated : observations being made of its rate of decay with time, of its variation with the p.d. used, and with the gas pressure in the apparatus. The strip is then covered with the salt to be tested and the observations repeated. Four samples of aluminium phosphate, two of sodium ortho-phosphate, and one of sodium pyro-phosphate are thus investigated, comparisons being made, in particular, at 1080° C. and 1190° C. In the experiments with Pt it is found that after leaving the strip cold overnight, a much larger current is obtained when first testing on the following morning. This abnormal current only lasts for a short time : in a few minutes the leak decreases to a steady value, usually somewhat smaller than on the previous evening. This decrease is accompanied by a slight increase in the electrical resistance of the strip, which suggests that some volatile product is subliming from its surface. From the curve given it can be seen that up to 320 volts the current is never completely saturated, but that after about 120 volts it increases approximately proportionally to the voltage. It is thought that the difficulty of saturating the current is due to the presence of slowly moving ions. The experiments described show that there are considerable variations both in the magnitude and in the permanence of the positive emission from different substances. In the case of Pt and of pure aluminium phosphate the initial emission decreases rapidly with the time, and in the course of a few hours' heating at a high temperature becomes extremely small. With sodium phosphate, on the other hand, the emission at first increases, and then decreases much more slowly than with the other substances tested : so that, after many hours' heating, a considerable current can be obtained. Impure aluminium phosphate falls between these cases. This is accounted for by the fact that impure phosphate contains sodium, which gradually disappears from the anode in the course of heating. The opinion is put forward that the ionisation from Pt (and from metals generally) is largely due to the emission of absorbed gases on heating, but that in the case of sodium phosphate a con-

siderable part of the emission consists of positively-charged sodium atoms, the final value of the current in a good vacuum, after long-continued heating, being almost entirely due to this cause, although at first there is a large current due to the evolution of ionised gas, which probably comes partly from the salt and partly from the Pt on which it is heated. It seems probable that the anode rays of Gehrcke and Reichenheim are essentially the same as the emission, in a good vacuum, from a positively-charged salt which has been heated until the steady state is reached. There can be little doubt that the large emission on first heating a Pt anode is due to escaping gas which comes from inside the metal in an ionised condition. It is difficult to see any explanation on the supposition that the ions are atoms of sodium or potassium. If the gas actually carries the current, we see at once the cause of the rapid fall of emission from a new wire, for when the wire is heated the gas pressure inside it is increased and the gas diffuses out until there is equilibrium between the internal and external conditions. When after long-continued heating equilibrium is attained, there are as many gas atoms or molecules entering the wire, in a given time, as there are emitted by the wire. The latter are ionised; a certain proportion of them (probably a very small proportion) are positively charged, and it is the charges carried by these which constitute the small "steady" current which is given by a wire that has been heated for a long time. It seems probable that some of the ionisation which is produced when certain salts are heated has its origin in chemical actions between vapours produced by these salts and the platinum on which they are heated. This view has already been put forward by Richardson to explain certain ionisation effects which he obtained when various salts were heated to a high temperature in a platinum tube. A. E. G.

853. *Some Characteristic Curves for Gases at Low Pressures.* **R. F. Earhart.** (Phys. Rev. 1. Ser. 2. pp. 85–95, Feb., 1913.)—The kathode used consists of a plate made up of ten concentric brass rings separated by an insulating material. Its face is in a horizontal plane and has a total conducting area of 85 sq. cm. The anode consists of a hemisphere of Pt, 2 mm. diam., mounted on a vertical brass rod which is covered with a thin glass envelope leaving only the hemisphere exposed. The anode is capable of adjustment vertically, but is always symmetrical with reference to the kathode. The discharge apparatus is contained in a bell-jar of about 10 litres' capacity. Characteristic curves showing the relations between current and potential under stated conditions of pressure and distance are obtained for air, hydrogen, and CO_2 in the region of the critical potentials. It is also found that the strength of a current through a gas at low pressures is determined in part by the size of the kathode. Empirical formulæ for the discharge from a positively-electrified point cannot be extrapolated from high pressure and potential regions to low pressure conditions. Introducing a constriction into the path of a discharge has the effect of increasing the apparent resistance of a circuit, this increase varying directly with the length of the constricted portion. A. E. G.

854. *Motion of Luminous Centres in Hydrogen Tubes.* **A. Perot.** (Comptes Rendus, 156. pp. 132–135, Jan. 13, 1913.)—The tubes used were of H-form, with Al electrodes, and were immersed, for cooling purposes, in a vessel of water. A dynamo furnished a current of 0·2 amp. at 10,000 volts; this could be regulated. An étalon 10 mm. thick was used, and the light from the tube passed through a red screen before reaching the étalon. If the light issuing from the end of the horizontal part of the H-tube is used, then the variation of wave-length produced on reversing the current is connected with the velocity v of the centres of emission by the relation $\partial\lambda/\lambda = v/V$, where V is the velocity of light. If the light from the horizontal tube is observed at a direction inclined to its axis and the current is reversed, the velocity measured (v') is connected with the velocity v by the relation $v = v'/\cos a$, where a is the angle the direction of the tube makes with the normal to the étalon. The two methods of operation have given the same numerical results. Three factors influence the velocity of the emission centres: the pressure, the intensity of the current, and the diam. of the tube. For a given tube at constant pressure the velocity increases with the intensity of the current. With a normal tube the following values were found, corresponding respectively to currents of 11, 16·25, 22 milliamps.: 149, 219, and 266 m. per sec. With a special tube whose capillary was 1 mm. diam., velocities of 815 and 1190 m. per sec. were found for currents of 100 and 144 milliamps. respectively. For the same current and constant pressure the velocity is greater the narrower the tube; and the ratio of the velocity to the square root of the current density does not vary much. For a given tube and a given intensity of current the velocity increases when the pressure is diminished, but in a certain pressure interval a tube can give different velocities according as the pressure is increased or decreased to the value considered. The greatest velocity observed was 1740 m. per sec. in a tube of 1 mm. diam., the current being 0·152 amp., giving a current density of about 0·2 amp. per mm.^{2}. This velocity is of the order of that found by the author for solar hydrogen, 3800 m. per sec. A. W.

855. *Velocity of Emission Centres in Hydrogen Tubes.* **A. Perot.** (Comptes Rendus, 156. pp. 310–312, Jan. 27, 1913.)—In a previous paper [see preceding Abstract] the author has shown that in a hydrogen tube the luminous centres move from the kathode towards the anode with a velocity which, measured by the Doppler-Fizeau effect on the red line $\lambda = 6563$, was found to vary with the pressure, the intensity of the current, and the diameter of the capillary. The present paper extends the results previously given. It was found that between certain pressure-limits the tube could exhibit two modes, the one with striations, the other without, and that in the first of these the velocities observed were greater than in the second. Experiments were made with a view to determining the velocity of the centres in different regions of a capillary showing striations. Using the method previously described, where the tube is inclined to the normal to the étalon, and projecting on the étalon an image of the tube, it was found that although the bright and dark regions could not be sharply isolated, the velocity of the centres is much greater in the bright parts than in the dark parts of the tube. Thus, with a pressure of 2·2 mm., current 0·1 amp., capillary 4·5 mm. diam., the velocity in the bright parts was 942 and in the dark parts 837 m. per sec. For a pressure of 3·3 mm. and the same current the maximum velocity was 625, the minimum 379 m. per sec. Wilson showed that the electric intensity is greater in the bright than in the dark regions of the striations; this fact is certainly connected with the results now obtained. Measurements were next made with the line $\lambda = 4861{\cdot}3$. With the same tube and the same conditions, measurements with the C and F lines gave different numbers, whose ratio appeared to be constant and equal to 1·6, the velocity measured with the line of shorter wave-length being the greater. This result is explained by the different damping of the two radiations. The ratio deduced theoretically is 1·8. A. W.

856. *Dielectric Cohesion.* **E. Bouty.** (Comptes Rendus, 156. pp. 25–28, Jan. 6, 1913.)—The apparent dielectric cohesion of a gas in a small bulb [see Abstract No. 664 (1913)] is $B = 1{\cdot}165b + 6$, where b is the normal dielectric cohesion as measured in large bulbs. For large values of b this makes B sensibly proportional to b : and in small bulbs the exterior field should bear to the field within the bulb the ratio 1·173 : 1, which is practically the same as the coefficient 1·165 above. The discharge in the bulb occasionally lags behind the external field ; more markedly in small bulbs. This seems to depend on a condition of the gas (*e.g.* the attainment of ionising velocity by the ions) adversely affected when the volume is small. The phenomena can be explained by considering the work done ($=y$ per unit of electric quantity) in the initial stage of disruptive discharge as divided into two parts : (1) that done along the course of the gas itself, proportional to the field and to the thickness ; and (2) that done at the electrodes or the wall, provided that this increase linearly with the pressure. This seems to be the case in neon. Experiment is necessary to see whether the coefficient 1·165 above is the same for all gases. A. D.

857. *Current Distribution at the Kathode of Discharge Tubes.* **A. Wehnelt.** (Deutsch. Phys. Gesell., Verh. 15. 2. pp. 47–52, Jan. 30, 1913.)—Goldstein has shown that at low pressure there are, in addition to the visible kathode-ray bundle, rays which issue from the whole kathodic surface. The author has made these rays visible by means of a screen, and has suggested that they are produced by the ultra-violet light given out during the discharge [see Abstract No. 1867 (1912)]. Now that a more sensitive galvanometer is used it is proved that this influence of the ultra-violet light is insignificant. Detailed descriptions of the apparatus and measurements taken are given. It is concluded that the kathode-ray bundle does not carry the whole current, but there are also positive ions which move up towards the kathode and ionise the gas at its surface. The ultra-violet light or soft Röntgen rays due to the discharge have also a slight influence by liberating electrons in the metal. A. E. G.

858. *Disintegration of Metals at High Temperatures. Condensation Nuclei from Hot Wires.* **J. H. T. Roberts.** (Phil. Mag. 25. pp. 270–296, Feb., 1913.)—In a preliminary account of experiments upon the disintegration of metals, more particularly the platinum metals, the theory was put forward that the disintegration of the platinum metals was due to direct oxidation [see Abstract No. 1767 (1912)]. That platinum does not, under any circumstances, combine directly with oxygen has caused a diffidence in suggesting that the influence of oxygen is other than catalytic, and there are, moreover, certain experimental facts which at first sight appear to militate against the theory that the disintegration is due to direct oxidation. In the present experiments, in which Wilson's condensation method is adopted, the wire is not placed in the expansion chamber, but in a separate chamber so that no water-drops can fall upon it. The wire is heated by a current developed from an alternator and transformer set. On their way to the expansion chamber the nuclei pass through an annular space, 2 mm. wide, between two brass tubes insulated from one another, the outer one earthed, the inner at —230 volts. There are two well-marked conditions governing the production of nuclei : (1) The recent history of the wire previous to the experiments. (2) The length of time since the commencement of experiments. There are two sets of nuclei : the first, got rid of after continuous

experimenting, depend upon the presence of hydrogen and other gases in the wire; the second depend upon the presence of oxygen round the wire: below a certain temperature the second set are never obtained. The metals experimented upon are platinum, palladium, rhodium, iridium, and ruthenium. It is found that platinum begins to disintegrate at as low a temperature as 500° C., but no loss of weight could be detected even after days of heating. The disintegration begins to come within the range of the balance between 1000° C. and 1100° C. The second set of nuclei even at 500° C. are very persistent, and do not change in size or character, being produced in pure oxygen, no matter how long the heating has been continued; they are not produced in the absence of oxygen. This shows that they are not likely to be either particles of the metal brought off by the escaping gas or traces of compounds of different gases. The rate of loss of weight of the Pt-wire is roughly proportional to the oxygen pressure, which points to the formation of an endothermic oxide. Experiments in a constant-volume gas chamber, in which the loss of Pt to loss of oxygen is determined, give results which approximate in the case of air to 2Pt : O and in the case of oxygen to Pt : 2O. It does not seem probable that this large amount of oxygen is simply adsorbed: it must be combined chemically, at any rate for the most part. During the cooling of the oxide after its formation at the hot wire some decomposition takes place, and the amount of the decomposition will be greater the lower the oxygen pressure. If we assume that the quantity of oxygen adsorbed by the deposit is small, the composition of the oxide in the experiments in oxygen must be either PtO_2 or some higher oxide. If the oxide is also present in the deposit in air, there must be a considerable amount of Pt mixed with it, this Pt being the result of dissociation of the oxide during cooling. The formation of an endothermic volatile and dissociable oxide not only explains all the observed facts, but will also explain certain facts in the discharge of negative and positive electricity from hot Pt-wires at low pressures. A. E. G.

859. *Duration of Luminosity of Electric Discharge in Gases and Vapours.* **R. J. Strutt.** (Roy. Soc., Proc. Ser. A. 88. pp. 110–117, Feb. 24, 1913.)—The object of the paper is to systematise and extend the somewhat scattered observations bearing on this subject. A new method of observing the "streamers" is described which in principle is as follows:—The electrodes are wires of the metal under observation. They are inserted into the opposite ends of a glass tube 1·5 or 2 mm. internal diam. so that the ends are about 5 mm. apart. A hole is blown in the side of the tube between the ends of the wire, and when the spark passes the metallic vapour formed is blown out of this hole, and out of the region of electric force between the electrodes. The volume of vapour formed is not enough to distinctly exude from the hole at atmospheric pressure; but the tube is arranged inside a receiver which can be exhausted, and the effect becomes conspicuous at a pressure of a few mm. of mercury. The vapour is shot out of the side hole in a distinct jet several mm. in length, visible by its own luminosity, which is seen to be continuous with that of the spark. When the metal is difficult to obtain in the form of wire, iron wires may be used, and a fragment of the volatile metal under investigation introduced into the gap, and in contact with one end of the wire. Vapours of the following elements are all found to give line spectra exclusively:—Na, Th, Ca, Zn, Cd, Hg, As, Mg, Pb, Se, S, P, I. Details of the glow appearances are also given. The effects obtained with the common gases H, N or air, O, and CO_2 are next described. As a result of these experiments it is concluded that the luminosity of the electric discharge survives the current not only in metallic vapours but also in the vapours of non-metals and in the permanent gases. It fades away in a continuous manner, and without immediate change of spectrum when the current ceases. Sometimes, however, a change of spectrum eventually results from unequal decay of the lines. These effects, which last less than 1/1000 of a second, are distinct, not only in degree but in kind, from the afterglows in nitrogen, in gaseous mixtures containing oxygen, and in gaseous mixtures containing hydrogen, previously investigated. These have durations extending in some cases to several minutes, and their spectra are from the first radically different from those of the exciting discharges. As previously shown, they are due to secondary chemical actions of substances produced by the discharge. A. E. G.

860. *Selective Absorption of Electric Waves.* **W. Romanoff.** (Ann. d. Physik, 40. 2. pp. 281–296, Feb. 4, 1913.)—The absorption of electric waves in alcohols is determined by the same method as that used by Zeeman and Eichenwald [see Abstracts Nos. 141 (1896) and 47 (1898)]. A wire system carrying the waves runs through the liquid of which the absorption is required and a thermo-element bridges the wires. From the ratio of two galvanometer deflections given by the thermo-element when placed at two points a known distance apart the absorption is determined. Care is taken that there are no interference effects due to reflected waves and that the galvanometer circuit is shielded from all stray electric effects. The wave-lengths vary from 50 to 100 cm. In every case the results show a strong dependence of the absorption on the wave-length. Maxima and minima of absorption are clearly observed, but the damping of the waves does not allow the absorption bands to appear very distinctly. T. P. B.

861. *Diffraction and Secondary Radiation with Short Electric Waves.* **A. D. Cole.** (Phys. Rev. 1. Ser. 2. pp. 2–15, Jan., 1913.)—An experimental research which may be summarised as follows :—(1) A study was made of the distribution of radiant energy with several arrangements of electric wave apparatus likely to furnish diffraction effects, including the opaque edge and slits. The effect of the screens increased the energy received at certain points and some cases analogous to diffraction bands were found. (2) The effect of shifting a pair of "screens" along the radiation axis was also noted. (3) The effect of a gradual change in the width of an opening through which radiation passed was studied for two points on the axis. Very little energy passed when the opening was less than a quarter wave-length ; with openings greater than one and a half wave-lengths more energy appeared beyond than when no screens were used. (4) Some resonance and interference results were obtained and are shown by curves. (5) Large absorption or obstruction effects were found when either a thick or a thin wire was placed at any point along the radiation axis if its length were parallel to the electric force. A flat strip reduced the intensity even more when placed edgewise than when broadside to the radiation. (6) When such a wire or strip was moved laterally by short steps from a central position strong maxima and minima were shown at the receiver. (7) One of Righi's "secondary radiation" experiments was repeated with the somewhat different apparatus here employed and his result verified. [See Abstract No. 320 (1911).] E. H. B.

862. *Radiation and Energy Dissipation of Electric Spark in High-frequency Circuit.* **H. R. v. Traubenberg.** (Ann. d. Physik, 40. 2. pp. 249–280,

Feb. 4, 1913.)—The radiation from an electric spark in an oscillation circuit is determined by means of a thermopile of special construction, which is standardised by means of a Hefner lamp. The total energy dissipated is determined by a calorimetric method. The heat developed in the electrodes is determined by means of a thermo-element. It is found that the radiation from a magnesium spark-gap is proportional to the product of the charge on the condenser and the discharge potential, other factors being constant. It is twenty times as great when sodium is used as electrode material as when silver is used. The radiation amounts to about 9 % of the total energy dissipated with a magnesium spark-gap. The energy dissipated depends on the length of gap in a manner analogous to that given by the Ayrton formula for the electric arc. The radiation- and chemical-energy dissipation of each electricity carrier appears to be about 10^{-11} erg. T. P. B.

863. *Electric Oscillations in a System of Three Coupled Condenser Circuits.* **F. Müller.** (Jahrbuch d. Drahtlosen Telegraphie, 6. pp. 335–352, Jan., 1913.) —This is the experimental part of a paper of which the theoretical part has already been abstracted [see Abstract No. 1744 (1912)]. Resonance curves of the oscillations in all three circuits are given, and these confirm the theory. An ordinary spark-gap, varying in length from 2 mm. to 8 mm., is used in the primary circuit. Impact excitation takes place in most cases both when the three circuits are in resonance and when only the first and third are. The best coupling for impact excitation of the third circuit when the second circuit is out of tune is found by experiment. When it has been found it is shown to be independent of the length of the primary spark, unlike impact excitation by Wien's method. T. P. B.

864. *Demonstration of Resonance Curves.* **F. Kock.** (Deutsch. Phys. Gesell., Verh. 14. 14. pp. 701–708, 1912.)—The author describes a somewhat modified form of his arrangement for recording resonance curves [see Abstract No. 1216 (1911)]. In the present apparatus a variable condenser, whose movable blades are rotated by means of an electric motor, is now used to bring the circuit into resonance each half-revolution, and a moving-coil galvanometer is arranged as an oscillograph in place of the Gehrcke tube formerly used. The beam from the galvanometer mirror impinges on to a mirror which is moved to and fro on a vertical axis by means of a crank on the condenser spindle. The rocking mirror furnishes the abscissæ, while the galvanometer coil, which has its axis horizontal, gives the ordinates. There is a semicircular slip-ring by means of which one of the resonance positions is suppressed (to avoid overlapping images). Some oscillograms obtained in this way are reproduced in the paper. L. H. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

865. *Preliminary Note on the Electron Atmospheres of Metals.* **R. W. Wood.** (Phil. Mag. 24. pp. 316–322, Aug., 1912.)—The author's experiments arose from an observation that a "half-silvered" quartz plate, having cross rulings 0·11 mm. apart, had an electrical resistance practically the same as that of an unruled film, although the cuts went clear through the film. The most suitable material for flat surfaces at minute distances apart was found to be speculum metal in the form of flats. Lycopodium spores allowed to settle on one plate

and then squeezed between the two surfaces gave quite considerable readings on a galvanometer. Similar results were obtained when the flats were separated with very small flakes of thin mica, thus excluding any possibility of conduction due to absorbed moisture. With the plates between 20 and 30 wave-lengths apart, metallic conduction commences with 1 volt of applied potential. It appears to the author that the separation can be much greater when mica flakes are present than when the gap is quite free from all material. L. H. W.

866. *Phase Factor of Coils in Resistance Boxes.* **W. Hüter.** (Ann. d. Physik, 40. 2. pp. 381–386, Feb. 4, 1913.)—A description of measurements, by Giebe's bifilar inductance bridge, of the effects of inductance and capacity in medium-sized coils in resistance boxes. The coils dealt with have resistances from 20 to 500 ohms, and were wound on the Chaperon system. The results are given in the form of values of the "Phase Factor" ($L/R - CR$), where R, L, and C are the resistance, self-inductance, and effective capacity of the coil. F. E. S.

867. *Note on the Energetics of the Induction Balance.* **J. P. Dalton.** (Phil. Mag. 25. pp. 56–60, Jan., 1913.)—In the generalised induction balance in which each arm contains resistance, inductance, and capacity, (1) the steady balance is conditioned by the usual Wheatstone relationship between the resistances, (2) an approximate impulsive balance is given by zero integral extra current in the galvanometer, and (3) a true impulsive balance necessitates zero extra current in the galvanometer at any time. The author shows how the ordinary solutions can be very readily obtained by a general energy theorem due to Heaviside. A. R.

868. *Method of Charging Electrometer Needle.* **A. H. Erikson.** (Le Radium, 10. p. 24, Jan., 1913.)—With a quartz suspension of a quadrant electrometer it is difficult to keep the needle continuously charged. In the present note a method of accomplishing this is described. A hollow cylinder containing polonium or other α-ray source and at a high potential is arranged so as to embrace the upper part of the needle which lies just above the quadrants. By this means an ionisation current passes into the needle and keeps it at the same high potential as the cylinder. A screen is arranged between the cylinder and the quadrants so that the working of the electrometer is not disturbed by the ionisation. E. M.

869. *Use of the Quadrant Electrometer for Measuring Large Resistances whether Variable or Polarisable.* **P. Vaillant.** (Journ. de Physique, 3. Ser. 5. pp. 36–46, Jan., 1913.)—The author discusses the limitations of the quadrant electrometer for a direct current. In the case of resistances which polarise the current or which vary rapidly it is advisable to substitute alternating currents. The latter method, however, has its limitations. The author then describes a quadrant method for the study of resistance variation due to any cause whatever. H. H. Ho.

870. *Resistance of Bubbles in a Liquid.* **P. Vaillant.** (Comptes Rendus, 156. pp. 307–310, Jan. 27, 1913.)—Discusses mathematically the great increase

of electric resistance of a column of liquid when polarised, and thence deduces a method of measuring the resistance of a bubble. E. H. B.

871. *Potential and Electromotive Force.* **W. Lenz.** (Archiv f. Elektrotechnik, 1. pp. 383–393, 1913.)—A discussion of the physical relations between these quantities, using a hydro-dynamical analogy. F. T. C.

ALTERNATING CURRENTS AND MAGNETISM.

872. *Susceptibility of the Binary Alloys.* I. *Antimony-Bismuth and Antimony-Zinc.* **K. Honda** and **T. Soné.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 11–16, Jan., 1913.)—The beginning of a systematic research on the para- and dia-magnetic binary alloys. The method was that of Curie [see Abstract No. 1335 (1910)]. In the first case, as the percentage of Bi in the alloy increases from 0 to 100, the susceptibility changes in an almost linear manner from $-0{\cdot}851 \times 10^{-6}$ to $-1{\cdot}382 \times 10^{-6}$. In the second case there are three eutectic points in the range, and the susceptibility has the values $-0{\cdot}851 \times 10^{-6}$ for 0 per cent. of Zn, $-0{\cdot}304 \times 10^{-6}$ for 35·48 per cent. Zn, and $-0{\cdot}145 \times 10^{-6}$ for 100 per cent. Zn ; the curve consists of two nearly straight branches between these points. [See also Abstracts Nos. 1516 (1910) and 1113 (1912).] G. E. A.

873. *Additivity of Diamagnetism in Compounds.* **P. Pascal.** (Comptes Rendus, 156. pp. 323–325, Jan. 27, 1913.)—Taking the coefficient of magnetisation of water as $-7{\cdot}2 \times 10^{-7}$, the author calculates the absolute values of the atomic coefficients of magnetisation of a number of elements from the coefficients of simple organic compounds. The calculated values thus obtained are in close agreement with the results of direct measurements made by various investigators on the elements themselves. When the above method of calculation is extended to metals, use being made of organo-metallic compounds, it is found that the atomic coefficient of a diamagnetic metal is not constant but diminishes as the molecular weight of the organo-metallic derivative containing it increases. But, in any homologous series of such compounds, *e.g.* that of mercury or tin derivatives, the value for the metal diminishes towards a limiting value which agrees almost exactly with the coefficient for the metal determined directly. Hence, with metals difficult to obtain pure, it is possible to ascertain the coefficients of magnetisation from those of their organo-derivatives. [*Erratum*, Ibid. p. 586, Feb. 17, 1913.]

T. H. P.

874. *Determination of the Magnetisation Coefficient of Water.* **P. Sève.** (Journ. de Physique, 3. Ser. 5. pp. 8–29, Jan., 1913. Paper read before the Soc. franç. de Physique, July, 1912.)—The absolute value of the magnetisation coefficient of water has become important, since recent researches upon the effect produced by a magnetic field on various bodies require water as a standard for purposes of calculation. Curie's value is usually adopted, viz. $\alpha = -0{\cdot}79 \times 10^{-6}$. The absolute value is especially useful in the case of feebly magnetic substances. The author discusses three previous methods due to Faraday, Gouy (the cylinder method improved by Wills), and Quincke, giving comparison values, and thereby showing the necessity for a new determination. Quincke's level method was finally adopted. Details are given as

to the magnetic fields employed and their evaluation. The conclusion drawn from the determinations is that corrections are necessary wherever reference has been made to Curie's values. H. H. Ho.

875. *Theory of Magnetic Hysteresis.* **G. Vallauri.** (Phys. Zeitschr. 14. pp. 118–120, Feb. 1, 1913. N. Cimento, 5. Ser. 6. pp. 41–46, Jan., 1913.)—Deduces the hysteresis curves of iron from Weiss's theory of ferromagnetic substances by a method analogous to that of Kunz [Abstract No. 1444 (1912)], but with correction of an error, which reduces the divergence between the theoretical and observed values of the hysteresis work from 63 per cent. to 32 per cent. E. E. F.

876. *Electron Theory of Magnetism.* **E. H. Williams.** (Univ. of Illinois, Bull. 10. No. 10. pp. 3–64, Nov. 4, 1912.)—A summary of the work done on this subject. It is divided into four parts, entitled respectively:—(1) Essential features of the electron theory of magnetism. (2) Experimental determination of the magnetic properties of crystals. (3) Effect of temperature upon the magnetic properties of bodies. (4) Experimental evidence in favour of the electron theory of magnetism. E. H. B.

877. *Sun-spots and Terrestrial Magnetic Phenomena* (1898–1911). **A. L. Cortie.** (Roy. Astronom. Soc., M.N. 73. pp. 148–155, Jan., 1913.)—In a former paper [see Abstract No. 701 (1913)] the mean seasonal variation in magnetic storms was attributed to the inclination of the sun's axis to the plane of the ecliptic and the position of the earth relative to the sun-spot zones. Selecting now the specially violent magnetic storms during the above period, a comparison is made between the times of their occurrence and the associated sun-spots. Certain peculiarities are evident. For instance, the year of maximum spots, 1905, was singularly free of magnetic storms. Tables are given of the magnetic data, areas, and positions of spot groups, etc. An important conclusion is that the most effective position of a spot group is entirely independent of the central meridian of the sun, although this relationship has been formulated by other observers. The westerly position appears to be more advantageous than the eastern. The characteristics of sun-spots accompanying the greater magnetic storms appear to be great irregularity of structure and rapid change, indicating great solar activity. The ratio of umbral area to the whole spot area is greater for spots associated with magnetic storms. C. P. B.

RADIOLOGY AND ELECTROPHYSIOLOGY.

878. *Use of very Soft Röntgen Rays in Radiography.* **T. Nogier.** (Archives d'Él. Médicale, 21. pp. 163–164, Feb. 25, 1913.)—Wood is very transparent to Röntgen rays of ordinary hardness, and it has been found almost impossible to make use of radiographs for its localisation when embedded in the tissues. Extremely soft rays of scarcely one degree Benoist are obtained by use of the special bulbs of Grisson and Bürger, the positive pole of the coil being connected to the anode instead of, as is usual, to the antikathode. The plates obtained with this apparatus contain good detail of the soft parts, but of course the bones give an almost opaque image. Small splinters of wood, even in the thickest part of the hand, can be readily distinguished. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

879. *Supposed Synthesis of Neon.* **W. Ramsay, J. N. Collie, and H. S. Patterson.** (Chem. News, 107. pp. 78–80, Feb. 14, 1913. From a Press report of a meeting of the Chemical Soc., Feb. 6, 1913.)—To find whether there was any transmutation due to β-rays, Ramsay broke old X-ray bulbs, and found traces of helium, neon, and argon. On heating them to 300° C. and collecting the gases, he found the spectra of He and Ne. Neon might conceivably be produced by the combination of helium and oxygen. Collie described some results of bombarding fluorspar and other substances with kathode rays, Ne being produced. That this Ne leaked in through the glass from the air was rendered improbable by surrounding the vacuum tube with Ne, which produced no distinct difference. On surrounding it with another vacuum tube, helium was found in the second tube. Patterson found that this helium, mixed with oxygen, gave neon $(4 + 16 = 20)$. The main hypothesis available for explaining these results, and the precautions taken are discussed. **J. J. Thomson.** (Nature, 90. pp. 645–647, Feb. 13, 1913.)—Adduces the difficulty of freeing glass from traces of H and other gases as an argument against the synthesis of neon. The glass of the vacuum tube may be heated to melting-point, the gases dried with charcoal and liquid air, and the incoming gases freed from hydrogen with the utmost care, the H lines will still be got by the positive-ray method, even when the bulb has been running for several hours a day for nearly a year. The only exception is when oxygen is kept continuously running through the tube. It then combines with H, and disperses the H lines as it does those of Hg. This production of H seems to be analogous to the production of He, Ne, and the new gas X_3. Almost any substance, when bombarded for several hours with kathode rays, yields X_3. The X_3 line is, as a rule, first accompanied by the He line, and somewhat less frequently by the Ne line. Lead may be evaporated until neither X_3 nor He can be detected in the vapour. But these will reappear when bombarding the remainder with kathode rays. E. E. F.

880. *Chemical Constants of Gases.* **O. Sackur.** (Ann. d. Physik, 40. 1. pp. 87–106, Dec. 31, 1912.)—The chemical constants of various gases are calculated according to the formula $C = (S' - C_p + R \log_e R)/2{\cdot}3R$, where S′ is the entropy constant. The values so calculated include H_2, $-2{\cdot}74$; N_2, $0{\cdot}33$; O_2, $0{\cdot}43$; H_2O, $-1{\cdot}18$; CO, $0{\cdot}35$; and CO_2, $1{\cdot}13$. They are smaller than the values given by Nernst, which, however, were based upon estimates of specific heat revised later by Nernst himself. The new values are applied to the calculation of vapour pressures, and give good results to a first approximation, both for molecules composed of identical atoms and molecules of substances containing several elements. More material is required for very high and very low temperatures. E. E. F.

881. *Influence of Impurities on Muntz Metal.* **F. Johnson.** (Engineering, 95. p. 288, Feb. 28, 1913.)—Experiments have been made with a view to placing on record the exact nature of the brittleness of Muntz metal made from certain brands of copper. The influence of small quantities of arsenic, antimony, and bismuth on the forging and cold-rolling properties have been

investigated; the results of which tests show that antimony is more detrimental than arsenic, and bismuth does not exercise the deadly effects in Muntz metal it does in copper. Maximum brittleness is, however, obtained in the combined presence of small quantities of arsenic and antimony. F. C. A. H. L.

882. *Deformation of Plastic Alloys and their Behaviour on Subsequent Reheating.* **A. Portevin.** (Comptes Rendus, 156. pp. 320–323, Jan. 27, 1913.)—By very slow solidification of molten alloys it is possible to obtain very large and homogeneous individual crystals. From such a crystal, containing 97·8 per cent. of copper and 2·2 per cent. of aluminium, a test-rod was prepared having a length of 17 mm., and its bases being rectangles 12·8 × 7 and 9·5 × 7 mm. respectively. An axial pressure of 600 kg. produced deformation of this rod, "slip-bands" being formed on the lateral faces, these being on any one face rigorously rectilinear and parallel. The first "slip-bands" are in a plane which is not parallel to the bases of the rod, the normal to the plane making an angle of 33° with the direction of application of the compressing force; this plane is one of the planes of sliding of the crystal and the components of the deforming pressure normal, and parallel to it are 5·2 and 3·4 kg. per sq. mm. respectively. If the elastic limit is regarded as corresponding with the first appearance, under a magnification of 200 diameters, of slip-bands, this limit varies considerably with the direction of the deforming force. With a mass of an alloy, which always consists of an agglomeration of variously orientated crystals, the phenomenon of deformation assumes great complexity. When the deformed test-rod was subsequently heated at 800° for 3 hours, it underwent disintegration into many small parts, the number of these apparently depending on the magnitude of the deforming force applied. T. H. P.

883. *Strengths of Thermally-treated Metals and Alloys.* **W. Müller.** (Metall. u. Erz, 10. pp. 219–230, Jan. 22, 1913.)—Compilations and diagrams of the results of tests on the strengths (breaking strength, elastic limit, elongation) of metals heated to different temperatures and slowly or rapidly cooled The metals and alloys dealt with are copper, zinc, nickel, aluminium, copper-zinc, copper-tin, copper-aluminium, copper-nickel, aluminium-magnesium, copper-zinc-tin, copper-zinc-nickel, and the chief authors quoted are Weidig 1911, Matweeff 1911, Martens, Grard, Guillet, Heyn, Baumann, Diegel. H. B.

884. *Tensile Strength of Copper-Zinc Alloys.* **J. M. Lohr.** (Journ. Phys. Chem. 17. pp. 1–25, Jan., 1913. Paper read before the 8th Internat. Congress of Applied Chemistry, New York, Sept., 1912.)—Gives the results of determinations of the tensile strengths of cast brasses containing 47·5 to 100% Cu. There is a slight increase in tenacity with the first addition of zinc to copper, after which the values remain almost constant throughout the α field, that is, to about 34% Zn. The max. tensile strength occurs at about 55% Cu, and is about 71,000 lbs. per sq. in. The β alloys give the highest tensile strengths. The variations in the tensile strengths agree very closely with the constitution of the alloys. Curves are given in which the results are compared with those obtained by Thurston, Mallet, Charpy, and the Alloys Research Committee. C. O. B.

885. *The Acicular Constituents of Alloys. Special Bronzes of Aluminium and Tin.* **F. Robin.** (Bull. Soc. d'Encouragement, 119. pp. 12–41, Jan., 1913.)—There are two types of microstructures consisting of interlocking

laminæ or needles: the Widmanstätten structure characteristic of prolonged annealing, and the martensitic structure characteristic of quenched solid solutions. A systematic study of the hardening, tempering, and annealing of aluminium and tin bronzes and a number of their ternary alloys has been undertaken with a view to a determination of the conditions under which the martensitic structure is produced and dissipated. In aluminium alloys the size of the needles obtained on quenching increases with the content of aluminium up to about 14 per cent. By quenching such an alloy from 1000° C., and subsequent tempering at various temperatures, it is possible to reproduce the sorbitic, granular, and laminated pearlitic structure of steels. The austenitic structure cannot, however, be obtained. By prolonged annealing at 800° C. the δ and α constituents give rise to the Widmanstätten structure locally. In tin bronzes the martensitic structure is not so easily produced, but can be obtained by quenching a 25 per cent. alloy from a very high temperature (just below the solidus). Quenching from the point of fusion produces large grains which are crossed with striations, but can nevertheless be compared with austenite. Tempering is much more rapid than in the case of the aluminium alloys. Similar experiments have been made on ternary alloys containing zinc, tin or aluminium, antimony, silicon, magnesium, arsenic, and the areas of alloys yielding the martensitic structure are indicated on the ternary equilibrium diagrams. The question of metallographic equivalence of the various metals is discussed, and laws are deduced for their determination. Excellent micrographs illustrate the paper and are discussed in detail. F. C. A. H. L.

886. *Influence of Divorce Annealing on the Mechanical Properties of Low Carbon Steel.* **H. M. Howe** and **A. G. Levy**. (Amer. Inst. Mining Engin., Bull. 73. pp. 1–35, Jan., 1913.)—In passing through the critical range, the change occurring in steel takes place in two stages: (1) the transformation in which the anstenite is split up into cementite and ferrite, and (2) the structural change in which the ferrite and cementite coalesce into separate large masses. While the first change is rapid, the second one is relatively slow. The process by which the cementite and ferrite are caused to coalesce severally and completely has been called "divorcing annealing" by the authors. Earlier evidence indicates that such annealing increases the ductility, but the results are contradictory as regards the effects on elastic limit. Steels containing 0·21 per cent. carbon and 0·05 and 1·19 per cent. manganese respectively were cooled at various rates from 900° C., while others were held in the upper part of the divorcing range (675–710° C.) for varying times, after which the mechanical properties and microstructures of the test pieces were examined. Etching with sodium picrate reveals the presence of structurally free cementite in a specimen which had been held at 685° C. for 23¾ hours. The first prolongation in the rate of cooling from iced brine quenching to air cooling has the greatest influence on the mechanical properties. The temperature of most active divorce is about 685° C., and maintaining at this temperature decidedly softens the metal and lowers its yield-point and tenacity. Further prolongation of the heating has no further influence on the elastic limit, but increases the softness. A given degree of divorcing with its attendant softening is obtained more quickly by a stay in the upper part of the divorcing range, followed by as rapid a cooling as possible compatible with avoidance of undue stress, than by a slow cooling from the critical range. Hyper-eutectoid steel would be expected to behave differently because of the presence of pro-eutectoid cementite, but experiments indicate that prolonged divorcing

annealing may increase the ductility of hyper-eutectoid steel to a degree far beyond that observed for hypo-eutectoid steel. It loses its ductility abruptly between 800° and 900° C., but a higher temperature is required to affect the elastic limit and tenacity to any considerable extent. F. C. A. H. L.

887. *Inverse Occurrence of Solid Phases in the Iron-Carbon System.* **A. Smits.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 871–880, Oct. 24, 1912.)—A highly theoretical paper dealing with the inverse appearance of solid phases in the iron-carbon system—a phenomenon which had previously only been met with in the cerium sulphate-water system.

F. C. A. H. L.

888. *Progress in Metallography,* 1909–1911. **E. Heyn.** (Rev. de Métallurgie, 9. pp. 934–982, Dec., 1912.)—Contains a list of references to 540 original papers.

889. *Wittorf's Iron-Carbon Diagram.* **B. Stoughton.** (Amer. Inst. Mining Engin., Bull. No. 74. pp. 227–237, Feb., 1913.)—The author briefly reviews Wittorf's work, which has already been dealt with in Abstract No. 1899 (1912). Attention is called to certain discrepancies between Wittorf's work and that of Ruff [Abstract No. 1619 (1911)]. F. C. A. H. L.

890. *Formation of Nitric Oxide in the High-tension Arc.* **F. Fischer** and **E. Hene.** (Ber. Deut. Chem. Gesell. 45. pp. 3652–3658, Dec. 28, 1912. Chem. News, 107. p. 144, March 20, 1913. Abstract.)—When pure oxygen is sparked and then mixed with nitrogen, six times more nitric oxide, NO, is produced than when the nitrogen is sparked and mixed with oxygen ; it is also better to spark the air (instead of oxygen) than the nitrogen. When air is sent through a high-tension arc produced in a cooled quartz tube and then at once mixed with oxygen, air, or nitrogen, the resulting volume percentages of NO are 7·8, 7·4, and 5·9. The yield of NO obtained in a Siemens ozoniser at different temperatures increases with rising temperature (up to 700° C.), because the velocity of the reaction is increased before the ozone is destroyed by the heat. It is concluded that it is the oxygen, and not the nitrogen, which is activated by the high-tension discharge. The dissociation of the oxygen molecule takes place within the arc and is endothermic ; without the arc exothermic processes lead to the recombination of the oxygen atoms to molecules and to ozone and to the formation of nitric oxide ; the NO is formed either by direct reaction between active oxygen and nitrogen or by the reaction between ozone and nitrogen. Technically oxygen (not air) should be passed through the arc playing between magnetite electrodes, and the gas then rapidly be mixed with nitrogen and cooled, the oxygen to be fractionated by the Linde method. H. B.

891. *Chemical Reactions at very Low Pressures.* **I. Langmuir.** (Amer. Chem. Soc., Journ. 35. pp. 105–127, Feb., 1913.)—A tungsten wire, heated in oxygen at very low pressures, begins to oxidise at about 800° K. (abs.), the brown or blue coating of the oxide, WO_3, being volatilised without dissociation at about 1200° K. Above the latter temperature, oxygen at pressures below 0·02 mm. acts on a tungsten wire at a rate which is strictly proportional to the pressure of the oxygen and to the surface of metal exposed. The rate increases with rise of temperature as rapidly as is the case with most chemical reactions at these high temperatures. No

fatigue effect can be observed, and the past history of the wire does not influence the results. The experimental conditions employed are such that: (1) a molecule of oxygen can strike the filament only once before returning to the surface of the bulb; (2) the velocity of the oxygen molecules is not affected by the temperature of the filament, the metal thus reacting with a gas at a totally different temperature; (3) the product of the reaction, WO_3, in diffusing away cannot influence the rate at which the oxygen comes into contact with the metal, as would be the case at higher pressures. The ratio, ϵ, of the observed rate of the reaction to the calculated maximum possible rate varies from 0·0011 at 1270° K. to 0·15 at 2770° K. Analysis of the experimental data according to the kinetic theory leads to the following conception of the mechanism of the reaction. The oxygen molecules which strike the filament do not react directly with tungsten atoms, but are first negatively charged by taking up an electron from the metal. On the average, about 30 electrons in the metal collide with the oxygen molecule during its contact with the metal, but only those electrons which have a velocity of 62×10^6 cm. per sec. or more succeed in charging the oxygen atoms. The number of electrons having such a high velocity is so small that only a few of the oxygen molecules impinging on the tungsten become negatively charged; thus at 1270° K. only one electron out of about 24,400 answers this condition, so that the number of oxygen molecules receiving a charge is about one out of a thousand. The negatively charged oxygen molecule is held by electrostatic forces to the positively-charged tungsten atoms, secondary reactions soon resulting in the union of the tungsten and oxygen atoms to form the oxide. This theory accounts for the observed values of ϵ between 1270° and 1770° K., and for the fact that the value of ϵ is independent of the temperature of the oxygen. [See Abstract No. 523 (1913).] T. H. P.

892. *Activity of the Ions and Degree of Dissociation of Strong Electrolytes.* **G. N. Lewis.** (Amer. Chem. Soc., Journ. 34. pp. 1631–1644, Dec., 1912.)—The author discusses more particularly the properties of strong uni-univalent electrolytes, with which alone the existing data permit conclusions free from ambiguity to be drawn. A very large number of chlorides, bromides, and iodides are equally dissociated, whilst nitrates, chlorides and bromates and salts of silver and of thallium are somewhat less dissociated. The degree of dissociation of uni-univalent salts is probably much smaller than commonly supposed. If it is assumed that the dissociation of potassium chloride is 74 per cent. at 0·1M, 82 per cent. at 0·05M, and 89 per cent. at 0·02M, then in all cases up to a few 0·01M, and probably in most cases up to 0·1M, the activity of the ions is proportional to the concentrations thus calculated. This view attributes the deviation of strong electrolytes from the mass law largely to a general increase in the mobility of the ions with the total ionic concentration, and differs essentially from the theory advanced by Franklin and Kraus and by Lewis and Wheeler. The latter theory regards the abnormalities of the conductivity curves for electrolytes as due to a change in the dissociating power of the solvent owing to the addition of a stronger electrophile as solute. According to the former explanation it is the velocity of the ions which does not obey the laws of the ionic theory, whilst, according to the latter, it is the degree of dissociation. Probably neither explanation alone is adequate, but the evidence here adduced in support of the view that the ions have a variable mobility in aqueous solution renders further investigation desirable. T. H. P.

893. *Relation between Ionisation by Kathode Rays and certain Chemical Effects.* **E. Jacot.** (Phil. Mag. 25. pp. 215–234, Feb., 1913.)—This work was carried out in order to ascertain what proportion of the so-called chemical effect of kathode rays is a direct effect such as Schmidt presumed [see Abstract No. 461 (1902)], and what proportions of it result from purely thermal effects of the rays and from a primary chemical effect on the gas or gases in the discharge-tube. Investigation of the action of kathode rays on white phosphorus showed this to be of twofold character: a purely thermal effect of the rays, resulting in the formation of red phosphorus, and a more directly chemical effect due to action of the corpuscles on the nitrogen in the tube, followed by a reaction between the modified gas and the phosphorus. The latter effect is proportional to the equilibrium ionisation of the nitrogen, but the total number of active atoms or molecules in the gas is of a much higher order than the number of ions present in the gas at the instant of combination. The function of the ions may be to assist a combination which does not otherwise take place. More probably the activity of the gas is not directly due to its ionisation, but rather to an atomising effect of the kathode rays on the gas—the active product being monatomic nitrogen, and the total number of modified gas molecules showing an exact proportionality to the ionisation in the gas by the rays. The ionisation in nitrogen by kathode rays is shown to vary inversely as the kinetic energy of the rays, for rays of velocities varying from $2{\cdot}92 \times 10^9$ cm. per sec. to $4{\cdot}76 \times 10^9$ cm. per sec. The ionisation also varies linearly with the pressure over the range 0·083–0·025 mm. of mercury. T. H. P.

894. *E.M.F.'s in Alcohol.* III. *Hydrogen Electrode in Dry and Moist Alcoholic Hydrogen Chloride.* **R. T. Hardman** and **A. Lapworth.** (Chem. Soc., Journ. 101. pp. 2249–2255, Nov., 1912.)—The influence of water on the e.m.f. of the hydrogen electrode in alcoholic hydrogen chloride at 25° is of the nature required by the solvate theory of acids, the quantitative results being in agreement with the affinity values of water and alcohol deduced by chemical methods. Additional experiments have been made with reference to (i) the e.m.f.'s of hydrogen ion concentration cells with solutions of hydrogen chloride in absolute alcohol as cell liquids, and (ii) the influence of temperature on the disturbance produced in such cells by addition of water. With ordinary concentration cells the e.m.f. increases nearly in proportion with the absolute temperature; but cells in which a moist alcoholic solution of HCl is set up against a dry solution decrease in e.m.f. in agreement with the requirements of the solvate theory as applied to these solutions. The fall in the basic "water-value" of alcohol as estimated by means of the hydrogen electrode is of the same order as that deduced by chemical methods, but appears somewhat greater. [See Abstract No. 616 (1912).] T. M. L.

895. *Electrolysis of Radio-active Substances.* **K. F. Herzfeld.** (Phys. Zeitschr. 14. pp. 29–32, Jan. 1, 1913.)—According to v. Hevesy [Abstract No. 1605 (1912)] the relative amounts of radio-active substances deposited by the electrolysis of a highly dilute mixed solution depend only on the potential, and not on the quantity present. The author modifies Nernst's formula for the kathode potential $E = RT \log_e (P/p)$ into the formula $E = RT \log_e (P'p_1/p)$, where P' is the solution pressure of the deposited atoms of the substance, p the osmotic pressure of those in solution, and p_1 the osmotic pressure corresponding to those deposited. This is justified by the consideration that the number of molecules deposited in unit time is only independent of those

already deposited when the whole electrode is covered with at least one molecular layer. Otherwise the number of ions redissolved is proportional to the surface covered, *i.e.* to p_1. The author shows that this modified formula gives a close approximation to v. Hevesy's curve. E. E. F.

896. *Electrolytic Processes.* **E. Grimsehl.** (Phys. Zeitschr. 13. pp. 1199–1202, Dec. 15, 1912.)—A Pt-wire is fused into a glass tube and then cut off level with the end of the tube, and the surface of glass and metal polished. When used as kathode in the electrolysis of very dilute sulphuric acid at a voltage of 110–220 volts, under certain conditions a fine stream of hydrogen bubbles is blown out in a peculiar manner at right angles to the surface of the Pt. This particular phenomenon (called by the author the "spirt phenomenon") depends on the concentration of the acid and on the voltage; the higher the voltage the lower the concentration of the acid necessary. With 100 volts the acid must be at least 0·01 per cent. strength. With the same concentrations the velocity with which the hydrogen is blown out is the greater the higher the voltage. When the concentration and voltage are kept constant the current strength is directly proportional to the radius of the electrode, and examination with a lens showed that the gas bubbles came off from the periphery of the electrode. Similar phenomena may be observed when the electrode is used as anode. Using the electrode as kathode, it is found that the potential-fall between the anode and kathode is mainly in the neighbourhood of the latter, 95 per cent. of it being within 0·1 mm. of the kathode. In the next series of experiments the Pt-wire of the electrodes projected a few mm. from the glass tube. When the "spirt phenomenon" was taking place it was found that the stream of hydrogen was deflected by an electromagnet as if it were negatively charged, and the stream of oxygen as if positively charged; the electrolyte may be either sulphuric acid, hydrochloric acid, or potassium hydroxide. By using an alternating current for electrolysis, and feeding the electromagnet with direct current, it was possible to deflect in the opposite directions the hydrogen and oxygen evolved, and collect them in separate receivers. If an electrode of zinc, similar in shape to that of Pt, is dipped by itself in dilute sulphuric acid, the hydrogen evolved is not affected by the electromagnet. If, however, it is then connected, outside the cell, with a Pt electrode immersed in the same electrolyte, only a very slight stream of hydrogen is given off, and this behaves towards the magnetic field as if positively charged. The hydrogen evolved from the Pt electrode is negatively charged. Lecture experiments are described for the demonstration of (1) the electrolysis of solutions of zinc chloride, and (2) the alteration in concentration on the electrolysis of solutions of sulphuric acid. T. S. P.

897. *Passive State of Iron.* **J. MacLeod-Brown.** (Chem. News, 107. p. 15, Jan. 10, 1913.)—It is frequently asserted that, if part of an iron nail or wire is rendered passive, the remainder of the nail or wire also assumes this state. That this is not so may be shown as follows:—An iron nail, 8 in. long, is immersed to a depth of 1 in. in concentrated nitric acid. The nail is allowed to drain, and the other end immersed to a depth of 1 in. in dilute nitric acid, when it will be found to be active; the passive end remains passive. If the nail is lowered into the dilute nitric acid, passive end first, the whole of it becomes passive after a short time. Other experiments are described in which it is shown that when a passive iron nail is connected by means of a Pt or copper wire to a nail of ordinary iron, the two nails being immersed in dilute nitric acid, that part of the ordinary iron which dips into the nitric acid becomes passive after a short time, the passivity being produced by anodic polarisation. The author considers that the passive state is conditioned by some definite arrangement of the particles at the surface of the iron. T. S. P.

898. *Time-lag between Electric Polarisation and Electrolysis.* **A. Grumbach.** (Comptes Rendus, 156. pp. 542–548, Feb. 17, 1913.)—If there be a time-lag between polarisation and electrolysis, a current-impulse of short duration should not evolve gas, though the same feeble current would liberate gas when acting for longer periods. The author confirms this by experimenting under the microscope with sulphuric acid and platinum wire electrodes, one very fine, closing the circuit for 1/12 sec. by means of a drop-switch. When the fine electrode had a diameter of 0·1 mm., an e.m.f. of 0·86 volt did not evolve hydrogen with instantaneous currents, but an e.m.f. of 0·92 volt did; the difference vanished as the electrode was made finer (0·01 mm.). The figures for oxygen (0·1 mm.) were 1·07 and 1·28 volts. H. B.

899. *Electrochemical Properties of Uranium X.* **P. Rossi.** (N. Cimento, 5. Ser. 6. pp. 5–14, Jan., 1913.)—Experiments on the electrochemical properties of uranium, both by electrolysis of solutions of its salts, and by immersing rods of various metals in them, show that the separation of U and UX is more difficult than for the elements of the radium family, which accords with the theory of Lucas [Abstract No. 1818 (1906)]. Contrary to this, however, UX is not more readily separable than U. Adding small quantities of other salts to the U solutions before electrolysis, *e.g.* $CuSO_4$, $NiSO_4$, or $FeSO_4$, to a solution of uranium sulphate, $AgNO_3$ to a solution of uranium nitrate, or lead acetate to one of uranium acetate, a deposit is obtained on the anode having an activity due entirely to UX, which the author attributes to absorption, and on the kathode a deposit which is either almost inactive or has an activity due as much to U as to UX. [See also Abstract No. 1057 (1910).] W. H. Si.

900. *The Resistance of Electrolytes.* **S. W. J. Smith** and **H. Moss.** (Phys. Soc., Proc. 25. pp. 133–143; Discussion, pp. 143–145, Feb. 15, 1913.)—In some experiments shown before the Physical Society in 1911, Haworth demonstrated that the resistance of an electrolyte depended on the frequency of the alternating current used [Abstract No. 1437 (1912)]. The authors point out that the method used is unsound, and have performed test experiments by a simple and direct method, which depends upon simultaneous measurement of the voltage between the ends of a tube containing the electrolyte and of the current passing through it. The former was measured by means of an Ayrton-Mather electrostatic voltmeter connected to auxiliary electrodes, and the latter by means of a Duddell thermogalvanometer. In the cases examined, using a solution of potassium chloride, it was found that the resistance of the electrolyte was constant within 0·05 per cent., whether steady currents or currents of any frequency up to 2300 alternations per sec. were used. T. S. P.